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TO ADVERTISERS

CHANGES for advertisements should be in this office by Friday noon for the following week's issue.

NEW ADVERTISEMENTS should be in the office not later than Monday noon to ensure publication in that week's issue.

On other pages of this issue may be found an illustrated description of the major features of the superb equipment of the Chicago Edison Company, together with some remarks upon its methods and the general character of its business. This corporation is one of the most successful which is conducting the business of public electricity supply in this country. Its management has always been marked by vigorous common sense, both as regards its financial and engineering details. The results are of extreme interest. What amounts to a new method of generation for local and extended electricity supply, by the use of double-current generators, is in use in this interesting installation.

METHODS OF ILLUMINATION.

The long and interesting discussion of the subject of methods of illumination which took place at the last Institute meeting, and which is elsewhere reported in full in this issue, brought out the fact that much uncertainty, much ignorance and much more or less thoughtless adherence to methods once in vogue, mark the application of modern illuminating methods.

One of the largest branches of the electrical arts is that of lighting. The subjects of the generation and distribution of electric current, and of its conversion by more or less efficient means into light, have been very thoroughly and competently studied. The subject of the utilization of the light after it is obtained has not enjoyed the same thorough and careful attention, and the consequence is that to-day a great deal of light is wasted and a great many eyes are imperiled by improper illumination methods.

Dr. Louis Bell, who seems to have taken upon himself the championship of better methods of illumination, has very powerfully urged the greater diffusion of light for interior illumination and has at least opened the eyes of many to the fact that in this matter—the utilization of electric light—there is an open field which will unquestionably reward all the study and research that it may receive. It is curious if one looks back at the history of electric lighting to note that, notwithstanding the extraordinary advantages of the incandescent lamp and the ease with which it lends itself to well-designed effects in interior illumination, the general practice has been simply to regard the lamp as a substitute for the gas burner and to install it in places where before its advent the gas burner had been supreme. In other words, many of the advantages inherent to the incandescent lamp were overlooked, and fashion, whose arbitraments are no less strong in engineering matters than in others, has made us familiar with the replaced gas jet and the street arc light set up on top of a glorified lamp-post.

It is pointed out in Dr. Bell's paper that an improvement of lamp efficiency such that the effective light due to a given amount of electrical energy would be doubled would cause almost a revolution. Yet this very same effect, he contends, can be obtained by the judicious use of reflectors and shades and the application of reasonable study to the average problems of illumination. This statement is sufficient to show the extraordinary importance of the subject and the value of the results that may be attained from its careful consideration.

THE EVERETT-MOORE SYNDICATE.

It has just been announced in the newspapers that the corporation known as the Everett-Moore Syndicate which controls a large number of street railway properties and telephone exchanges in the middle western states has met with financial difficulties and has been obliged to surrender its affairs into the hands of a board of trustees. The announcement, as is common when such statements are made, created for the moment a feeling of alarm perhaps upon the holders of certain securities and caused some apprehension on the part of the depositors in banks known to have large holdings of the syndicate's securities. The facts seem to be that the compelling cause of the failure was too great eagerness to extend and an injudicious expansion at a time when it is becoming more difficult to obtain readily large sums of money for such purposes. It should not be forgotten that the properties represented are in no way less successful than they have been before, nor is their earning power in any degree less. While all must deplore the embarrassment which has come to this syndicate, still there is no reason to feel any undue alarm in regard to the future of the properties

concerned, nor should this occurrence in any way shock the faith of the public in such securities as street railway and telephone stocks and bonds. It has become necessary in this country of late to exploit companies holding the securities of other companies as their sole assets. Such things are to be looked for in a period of general commercial expansion, and it is believed that the readjustment of these conditions, which sooner or later is inevitable, will prove in no way detrimental to the industry at large, but perhaps will further develop itself into a more or less disguised blessing.

PRESENT TENDENCIES IN ELECTRIC TRACTION.

On other pages of this number Dr. Louis Bell reviews the present tendencies of electric traction extension at some length and in his usual interesting style. The burden of his remarks is that a railroad is a railroad, whether it be operated by steam, electricity or any other power. This evident truism seems to have been overlooked to a very great degree by railway engineers and managers, and for years past electric railways have been thought of, written of and actually operated as if they were in some essential respect different from any other kind of railway. As a consequence, methods properly applicable to street tramway lines have been extended to interurban lines, which are, to all intents and purposes, railroads, and a happy-go-lucky state of things has supervened which has borne fruit in an increasing number of accidents on electric railways.

The experience of about seventy years of railway operation in this country should have taught more lessons than appear to have been received and digested by the average exploiter in interurban trolley systems. All that has been learned concerning permanent way, track and operative methods applies equally as well to electric railways as it does to their steam operated prototypes. And it should not be forgotten that there is an essential difference between the street tramway and the cross-country railroad. Here, indeed, is the real difference; not in operative method or in motive power, but in class and character of service. Consequently, as Dr. Bell points out with great clearness, the most dangerous mistake which is liable to be made now by electric railway engineers is to consider the interurban line as an extension of the street railway, and not as actually a railroad which may or may not use the street railway line as a feeder if this be expedient.

SEEING BY WIRE.

About every six months there crops up in the newspapers an account of the achievement by some one of a design for visual communication by wire. Almost invariably the inventor resides at the ends of the earth or in the backwoods.

Ever since Professor A. G. Bell devised the photophone and succeeded in transmitting sound impulses over a beam of light, the idea of transmitting pictures or appearances, or light in some form over a wire, has exercised a peculiar fascination upon inventors. It was thought for a long time that the development of the peculiar electrical and absorptive properties of selenium might show a way for the design of such a system. But the further knowledge which has since been obtained of the behavior of this substance does not bear out this view, and it is not now believed that it can be used in this connection.

A number of more or less intelligent methods have appeared from time to time, but so far none of them has met even with the faintest appearance of success, and the subject remains to-day about where it was when it was first thought of fifteen or sixteen years ago. There is no doubt that such an improvement would be of use could it be made. At the same time it does not to-day appear as if there is any hope for it, and those who put faith in scientific articles in Sunday newspapers are warned to look twice before they believe much in this direction.

The admirable series of articles by Professor John B. C. Kershaw, reviewing the status of the electrochemical arts, is concluded in this issue. Nowhere before has the immense importance of this development of electrical engineering been made so manifest, nor has any other statement concerning it so clearly shown the future industrial importance of this electrical application.

ELECTRICAL PROGRESS IN 1901.

When the first year of the twentieth century opened there was a feeling, sometimes expressed, among electrical engineers that the achievements of the nineteenth century, which had just passed into history, would never be equaled—that progress could go no further than it had gone and that the development of the electrical engineering arts in the future would not exhibit those great strides in advance which had characterized it during the preceding decades, but would continue rather as a steady and relatively slower development.

In looking back over the record of the year 1901 it is evident that these opinions were entirely mistaken and that no year, except perhaps 1876, which saw the commercial introduction of the electric light and the invention of the telephone, can be compared for the magnitude of the advances made in it with the year just passed.

During the first week of the new year it was announced that arrangements had been concluded whereby the American Telephone and Telegraph Company became possessed of Dr. Michael I. Pupin's patents for distortionless telephone circuits. This invention, completed during the summer of the preceding year, marks, perhaps, the largest advance that has been made in the art of telephony since the invention of the bridging bell. Its immediate effect is greatly to extend the possibilities of long-distance telephony and immensely to facilitate the operation of large exchanges in great cities wherein, of necessity, much mileage of cable is encountered in ordinary conversations. In another place in this issue this revolutionary innovation is described more fully and the progress of its application to-day is detailed.

In the direction of wireless telegraphy tremendous advances were made during the past year. At the beginning of the year Professor Doctor A. Slaby made public some researches of the most interesting and important variety, showing the possibilities of syntonic wireless telegraphy, and somewhat later Mr. William Marconi also brought out an elaborate system of apparatus for the same purpose.

The system devised by the latter and his associates was, during the year, very greatly extended, especially in England and upon vessels plying between British and American ports, and also at stations in the North Sea. About the middle of the year the Nantucket Shoals lightship, anchored at a point southeast of the Island of Nantucket and lying nearly in the course of vessels passing between New York and points on the British Channel, was equipped with apparatus for wireless communication with the mainland so as to be able to report passing vessels. The United States Weather Bureau, under the control of the War Department, also during the year has carried on a long series of experiments for the application of wireless telegraphy methods in receiving weather signals, etc., and the United States Navy has lately been equipped to some extent with apparatus of this character.

But the crowning achievement of the year was made on December 14, when signals were received in Newfoundland from a station in Cornwall, England, across 2,200 miles of sea. When, during the year before, signals had been exchanged across the British Channel at its narrowest point and a new method of communication set up between the mainland of Europe and the British Islands, it was considered a marvelous and extraordinary accomplishment. Within one year, however, the progress of wireless telegraphy has been so great that the Atlantic has been bridged and a new method of signaling has successfully operated over the busiest of the seas. Of this achievement and its consequences more is told in another place in this issue.

In the art of electric lighting, interesting and substantial advance has been made. Perhaps the most important work that has been done during the year has been the commercial development of the Nernst lamp. In August, at the meeting of the American Institute of Electrical Engineers at Buffalo, this lamp was exhibited in its commercial form and fully described by Mr. Alexander J. Wurts. Other developments which have been made during the same time are the constantly increasing extension of the enclosed arc lamp, both for direct and alternating-current systems, and the increasing use of electric light for decorative purposes.

The Pan-American Exposition, which was held last summer, exhibited the most magnificent and wonderful example of decorative electric lighting that has ever been shown. In its entirety this effect was accomplished by the use of eight-candle-power incandescent lamps fed by current received from Niagara Falls over a transmission line twenty-nine miles long. The effect has been so often described that it is useless here to attempt any account of its extraordinary beauty. Without doubt this illumination has shown the way for all others of the same class hereafter.

In the field of the telephone progress has been made along a number of lines. The most notable engineering progress has been the utilization of the Pupin patents, mentioned above, and the change of system in numerous large exchanges from the older distributed battery type to the common battery type. In New York city the last of the great exchanges maintained by the New York Telephone Company was changed over in December. The advantages of the common battery system are too well known to need repetition here, and include reduction of maintenance cost and improvement both in capacity and quickness in operation of switchboards.

Another development, along different lines, has also been taking place in the telephone field, this being the continuous and rapid growth of independent telephone properties and organizations. It is conservatively estimated that the present extent of this business includes more than 700,000 telephones connected to exchanges, with a very large number in operation on private and intercommunicating lines. Any mention of the telephone field would be incomplete without reference to the increasing extension of automatic telephone apparatus. During the year a fine exchange of this character was put into operation at Fall River, Mass., while others are under construction in various parts of the country.

Early in the year a decision was handed down in the United States Circuit Court, at Boston, Mass., by Mr. Justice Brown, declaring the long litigated patent of Emile Berliner to be invalid. Up to this time the extension of independent telephony has been practically based upon hope for such a decision, and its announcement at once validated and strengthened much that had been done and that was in contemplation in this direction.

In the spring of the year, at the conversazione of the American Institute of Electrical Engineers, Mr. Peter Cooper Hewitt exhibited for the first time a new form of electric lamp in which mercury vapor was made to glow, under the passage of electric current through tubes containing it, with a powerful light of high efficiency. This form of lamp was justly regarded as the longest step that had yet been made in the direction of the production of light without heat and its invention may be set down as one of the notable achievements of the year 1901.

At the meeting of the American Institute of Electrical Engineers on May 25, 1901, Dr. A. E. Kennelly described for the first time the new storage battery due to Mr. Thomas A. Edison. In this battery a very important advance was made in the direction of specific lightness of the element, continuous output rate and decrease of depreciation in use. Its announcement was immediately regarded as one of the most important that had been lately made and the invention is one that is likely to rank as among the most noteworthy announced during recent years in this field.

Turning now to the field of electric railways, marked and notable advances have been made during the year on both sides of the Atlantic. The movement of the year before for the consolidation and extension of interurban electric railways was carried on to a considerably further extent, and many miles of additional track were built. The electric elevated railroad in Boston was opened to the public and the completion of the electrical system for the operation of the elevated railroads in New York was brought to a point such as to admit of tests of the finished equipment. Just before the close of the year it was definitely announced that the Pennsylvania Railroad Company would build a large underground terminal in the Borough

of Manhattan, New York city, connected to its tracks in the state of New Jersey and to those on Long Island by a system of tunnels in which electric traction would be employed. This is justly regarded as the first great step in the electrical equipment of American steam railroads, and may be looked upon as one of the most important practical steps taken during the year 1901 in electric traction matters in the United States.

Turning now to the European situation, much of great interest and importance has been accomplished in this field. Under the immediate inspiration of the German Government experiments in polyphase traction at enormously high speeds were undertaken on a military railroad near Berlin, where speeds considerably in excess of 100 miles per hour have already been attained. The fine system of electric railways operating by polyphase currents in the Valtellina regions in the north of Italy was opened to the public, while both in Paris and in London several important extensions of the underground electric railway systems already installed in those cities were made. In addition to this the electrical equipment of tramroads and interurban lines of various parts of the British Islands and the Continent has proceeded with renewed and awakened activity.

In the field of the telegraph perhaps the most important achievement of the year was the final decision to construct at once a cable connecting the United States with its new possessions in the east and thus, by making a transpacific line, to complete the chain of electrical communication around the earth. Notable improvements in service have been made both in the United States and abroad, these being particularly in the direction of high-speed telegraphy and in the superior construction of new lines to withstand storms and other destructive influences. In the latter part of the year an extensive tempest caused great destruction of land lines in the British Islands and proved incontestably the very great value of the underground circuits already in existence between London and Birmingham. It may be noted also that in the United States several interesting patents were taken on page-printing telegraph systems, and that some of the latter have found considerable application in the financial district of New York for the distribution of financial intelligence and the stock market reports.

In electrochemistry prodigious advances have been made in the direction of constructing new plants and in the applications of electrochemical methods to producing new lines of products. The calcium carbide industry has attained a great steadiness of production, and aluminum, which may fairly be classed as an electrochemical product, has come more and more largely into use, especially for power-transmission lines. Electrochemistry has been called in to assist in the manufacture of a great variety of substances hitherto made by other processes, notably such as bisulphide of carbon, caustic soda, chlorate of potash, iodoform and a host of synthetical products used in medicine, the laboratory and in the arts of dyeing, etc.

In power transmission most noteworthy steps have been taken, especially on the western coast of the United States. Here, during the summer of 1901, was inaugurated the longest power transmission yet attempted—two hundred and fifteen miles—from a point in eastern California on the Yuba River to San Francisco and Oakland, and with numerous ramifications and intermediate stations. Upon this line potentials as high as sixty thousand volts have been successfully handled for commercial use. Power transmission also has largely been applied to the distribution systems of great electrical supply concerns, both for lighting, power and street railway purposes. Indeed, one of the most notable features of the year's development in the United States has been the standardization, if this term may fairly be used, of high-potential polyphase-transmission systems for street railways and the like.

In the field of pure science perhaps the most valuable contribution of the year has been Professor J. J. Thomson's astonishing research upon masses smaller than atoms, and from it the outgrowth of a new physical theory named, for the present, the "corpuscular hypothesis." This new hypothesis has shed a perfect flood of light upon many of the strange and hitherto unaccountable phenomena observed in the passage of electric current through vacuous spaces, and has also been of considerable assistance in the formulation of better and more coherent ideas concerning the phenomena of electrochemistry and the physical existence of ions. The conception of the latter, that is, of the existence of charged masses of molecular and atomic size and smaller, has probably prepared the way for another great generalization and an enormous advance in the confluent sciences of physics and chemistry.

To sum up the progress of the year, it may be said that in every direction has been advance and in all departments such steps have been taken as mark the beginning of the twentieth century as a year of unusual progress. Practically with the coming of the new century has come the new realization that electrical engineering is embracing many departments of applied science that hitherto were thought to have no immediate connection with it. In the work of the mechanical, the civil and the chemical engineer, electricity is now taking a foremost place as one of the instruments at his command. No period has ever opened with higher promise than does the new year now before us. If the record of progress established in the first year of the new century keeps up through the remainder of it, the nineteenth century, brilliant as were its achievements and magnificent as was the advance of civilization in all directions during that time, will be paled into insignificance by the achievement of the twentieth.

Last week, in one night, two people in New York were asphyxiated by gas, and a gas main in a residence street blew up, wrecking several buildings, setting fire to its surroundings and nearly scaring several people to death. And yet we hear of the deadly electric wire!

There is a large demand for a simple, cheap and efficient clock-controlled time switch. This offers an excellent opportunity to inventors and seems not to be a very difficult problem to solve.

Methods of Illumination and Units of Light.

Papers and Discussions at the One Hundred and Fifty-Ninth Meeting of the American Institute of Electrical Engineers, January 3, 1902.

THE one hundred and fifty-ninth meeting of the American Institute of Electrical Engineers was held in New York on the evening of January 3, 1902, the subject-matter of the evening's programme being "Methods of Illumination and Units of Light."

About two hundred members were present and the hall was illuminated by five of Mr. Peter Cooper-Hewitt's mercury vapor lamps.

The meeting was opened by President Steinmetz, who said:

"The problem with which we are concerned in developing methods of illumination is the transformation of energy into that variety of radiation which lies within the visual spectrum. It should not be forgotten that light is a physiological phenomenon. Only a certain small and relatively very limited portion of the spectrum of the ordinary radiating body is visible to us as light. The endeavor must be made, in order to obtain efficient light, to condense radiation as far as possible in this visual part of the spectrum, and to suppress the radiations of other characters which are useless for the purpose of illumination. Until the latter part of the last century the only means by which luminescent phenomena could be arrived at was through combustion in some one or the other of its forms. With the general development of electricity new means were introduced, but in practically all of these heat was still retained as the active agency. The efficiency of transformation between the jumbled and confused vibrations known as heat and the sharper and more defined waves known as light is necessarily very low." The speaker considered that an essential improvement can be found only by direct means.

"The three varieties of light-making phenomena in use for illumination are incandescence, heat luminescence and electric luminescence. The efficiency of any method employing incandescent radiants is limited by the temperature to which the glowing substance can be carried. Even carbon at its boiling-point exhibits too low an efficiency. This point is realized in the arc lamp. Certain metallic oxides appear to have abnormal radiating powers, and as transformers of heat into light are more efficient." By heat luminescence the speaker meant such phenomena as are exhibited in the Welsbach light and in the Nernst lamp. By electro-luminescence was meant electrical excitation of non-conducting gases set in luminous vibration. The wave-length in this case is no longer a function of the temperature and the efficiency of conversion of energy into radiation is good. The efficiency of such apparatus as light-givers becomes high when the radiation falls within the visible spectrum.

The first paper of the evening was read by its author, as follows:

METHODS OF ILLUMINATION.

BY LOUIS BELL.

At the risk of being iconoclastic, I am here going to discuss the art of illumination from its human and practical side rather than the technical details of electric lighting, and to compare methods as bearing upon the result rather than in their theoretical relations.

Artificial lighting, in some form or other, has come down to us from the very dawn of history, but without material change in methods and apparatus until well into the last century. Its resources have been vastly increased within the past seventy-five years and have grown up with the rise of what one might call technical civilization. The development of electric lighting which has taken place during the last quarter century has enriched the art with extraordinary facilities, and it is the bearing of these upon the art in general and upon each other that forms the subject under discussion.

Now, at the very outset, I must confess the profound conviction that as things are at present we are using the tremendously potent means at our command with a reckless indiscrimination that in the long run profits little to art or civilization. We have contracted in no small degree the modern and peculiarly American vice of megalolatry, if one may venture to coin the word, and estimate illumination like many other things—by the magnitude of the display.

It is difficult to realize in this the change that a century or so has wrought. As nearly as we may estimate from the somewhat meagre data that have come down to us, the most splendid fête in the days of Louis Quatorze glittered with less than a fifth the illumination that makes conspicuous the bourgeois tawdriness of a twentieth century function, but who shall care to say that ratio represents a gain to art or a new conception of regal magnificence? Art and civilization do not necessarily gain with added physical resources. Better the rush light that shone on the wine-stained doublet of Will Shakespeare than the electric arc with Mallock and Oscar Wilde.

The truth of the matter is that with the immensely powerful sources of light now at our command, there is a constant and often reprehensible tendency to turn on more and more light irrespective of quality and of actual needs until the net result is loss rather than gain. We too often forget that illumination is a problem at once physiological and physical, and that by reckless profusion of light it is a perfectly easy matter to key the vision, as it were, up to a pitch which demands extraordinary methods to produce the most common-place results.

It is a fundamental physiological fact that the eye works equally well, sees with equal facility, within a very wide range of illumination. True, as the light intensity is reduced, a point is finally reached at which the normal eye begins to labor and strain, picking out details instead of grasping the whole, but it is equally true that if the lighting is carried above a certain intensity the eye reaches a point where it not only gains nothing in case of perception, but suffers from over-stimulation. Between these limits, varying obviously for different tasks, there is no intrinsic reason for increasing or diminishing the illumination except in so far as a reason may be sought in convenience or economy.

Whatever the methods employed the end of artificial lighting should be to furnish illumination in quantity fully adequate for the conditions to be met, and in quality such as will neither unduly strain the eye nor in any way inconvenience the user. It is the adaptation of means to end that should be sought here as everywhere else. From this standpoint, quality is more important than quantity. It is no easy matter to define the quality of light in any simple terms. Certain qualities, however, must be possessed by any really good light in order that it may not do positive injury to the eye and may prove efficient visually. The three most important qualities for a practical illuminant are, in the order of their importance, as follows:

1. Steadiness.
2. Suitable intrinsic brilliancy.
3. Suitable color.

1. Steadiness—The importance of this property can not be overestimated, for without it in a rather high degree an illuminant is both impracticable and dangerous to the eye. An unsteady light works evil in two distinct ways, somewhat different in their relation to the physical properties of the light. In the first place we must remember that the eye is provided with a partial defence against unsteadiness in the visual inertia given by the persistence of retinal impressions, and in addition it has the iris working automatically to steady the amount of light which reaches the retina.

A flickering, unsteady light may injure

the retina through overworking it by a rapid succession of violent stimulations, or it may tire the automatic mechanism of the iris, or it may do both. The iris is peculiarly a defence against slow changes in illumination. At full aperture it has fifteen or twenty times its area at minimum aperture, or perhaps double this ratio under extreme conditions, but its time constant is large, several seconds, and in an unsteady light it never gets a chance to settle into a position of equilibrium. Visual inertia is a defence against very rapid changes, but not against slower ones, and there is a wide range of frequency between the point at which visual inertia fails to protect and the point where the iris can give material aid. Within this range unsteadiness, whether accidental or periodic, may be both distressing and dangerous.

Let us try, if possible, to get a quantitative conception of this case. The frequency at which flickering in incandescent lamps becomes annoying is a much mooted point, the view of the debater generally depending on what he has to sell. The real question, however, is what variation in amplitude of illumination constitutes an amount which is physiologically serious if periodically repeated. Obviously a change from light to darkness is vastly worse than a small change in brilliancy at the same frequency. Eyes differ in sensitiveness, but in my own case I have found that a variation of ten per cent at the rate of one or two maxima per second is very annoying and tiring. This observation was made, by the way, with the potent assistance of a pumping synchronous motor which could give variations in voltage up to five volts on an ordinary incandescent circuit. Retinal persistance is, of course, a very variable phenomenon, but for a rough approximation, taking this constant at one-fifth second a ten per cent falling off in brilliancy would correspond to about one-fiftieth second, and one would feel entirely safe in saying that sudden flashes one-fiftieth second apart would cause trouble at once, and, probably owing to frequent recurrence, very serious trouble. In point of fact, an alternating arc worked with small current density gives such a succession of flashes, and in spite of a certain amount of thermal stability would be quite impossible at twenty-five cycles, and is bad even at one hundred cycles per second. Incandescent lamps, having greater thermal stability, present smaller fluctuations due to frequency, but are very bad at fifteen cycles to twenty cycles, and show fluctuations troublesome to some eyes up to and even above thirty-five cycles.

Under conditions of prolonged use, fluctuations considerably less than ten per cent may become troublesome, as is well shown by the evil effects of flickering gas burners, in which the changes of absolute intensity are small. Here, of course, the phenomenon is complicated by flickering at the edges of the retinal image, but taking all the facts together I think that one may safely say that any source of light subject to rapid and frequent variations as great as five per cent is unfit for use as an illuminant for work requiring steady use of the eyes. Much greater changes, occurring slowly enough for the iris to act with them, or at infrequent intervals, can be tolerated without inconvenience.

2. Intrinsic Brilliancy—The brightness of the radiant used in artificial lighting is a matter of great physiological moment. If the image of a brilliant light remains on one point of the retina it may and probably will produce serious overestimation, and a bruised spot, as it were, may become the nidus of painful and dangerous inflammation. Any oculist can report a long list of serious or destructive injuries due to this cause. On the other hand, if the image wanders over the retina rapidly it produces, in a minor degree, the same unpleasant result experienced in coming suddenly from a darkened room into bright sunshine. Especially is this true if the brilliant radiant now and again dodges into the field of vision without giving the iris a chance to act. The fundamental rule of proper illumination is to keep brilliant radiants out of the field of vision. Apart from the mischief done, the iris in the presence of such a radiant shuts up as far as possible, and objects not brilliantly illuminated are seen with great difficulty. Hence the common experience of being unable to see across an arc light, and the serious difficulty thrown in the way of pilots by searchlights unwisely displayed. It is a common experience, too, that shading a brilliant radiant may greatly improve the seeing conditions in a given space while actually reducing the available illuminator. It is almost impossible to get a quantitative measure of such a gain, though it is often quite marked. The ingenious illuminometer of Messrs. Houston and Kennelly, and the tint-comparing instrument of Mr. Bijur, another fellow member, both break down here, since they work a shielded eye.

The real criterion of visual usefulness is not the illumination I, but the product $I\,\sigma$ where σ is the effective aperture of the iris, and since this latter factor is a function of the brightest radiant in the field, we may properly write the criterion:

$$\frac{I}{f(B)}$$

where B is the intrinsic brilliancy of the radiant. This whole subject needs investigation, but like other matters involving subjective facts, it is very hard to get at. We can, however, get an approximate notion of permissible values of B for practical purposes. The experiment of L. Weber on intrinsic brilliancy give a clue to the conditions found in practice. Reducing them to mean values and candle-power per square inch some of his results are as follows, approximately:

Horizontal white card, brilliant sunlight	25
White sunlit cloud	7
Argand burner	6.5
Horizontal white card, dull winter day	0.26

Now there is no doubt whatever that the intensity first mentioned is far too great for comfort, considering the normal eye. It is, in fact, extremely trying. The second and third most of us would consider rather uncomfortably bright if they were fairly in the field of vision, and all the experience along this line seems to indicate that for radiants within the field of vision at the distances ordinarily met with in interior lighting an intrinsic brilliancy of five candle-power per square inch is about as high as it is wise for hygienic reason to go, and better rather less than rather more. This indicates at once for the radiants in common use that they should never be employed within the working field of vision without diffusing shields to keep down the intrinsic brilliancy.

Obviously with the given limit of intrinsic brilliancy the diffusing globes must be of fair dimensions. With proper diffusion the entire globe surface may be taken as the radiant, and for a first approximation the radius of a spherical diffusing globe should be at least

$$r = \frac{C\,P}{5\,\pi}$$

C P being the candle-power. With very high intrinsic brilliancies, such as are given by arc lamps, it is hard to avoid the appearance of a nucleus of great brilliancy, and proper diffusion means considerable loss of light. But arcs should be kept for the most part out of the working field of vision, so that this objection is not so serious as might otherwise be the case.

3. Color—It is not necessary that artificial illuminants should conform to a particular color standard, save where color is a matter of prime importance. It is, however, true that the general applicability of a light is very strongly influenced by its hue, and that broadly, strongly colored lights would fail conspicuously in visual usefulness. Quite aside from the matter of color perception, it is the orange, yellow, and green that make up the working luminosity of the spectrum formed by sunlight to the extent of about eighty per cent, and even were a brilliant deep blue or red light produced it would require far greater energy for the same luminous effect than a yellow or greenish light.

The eye unquestionably does its best work by light approximately like that through which it has been evolved. But sunlight is a very variable quantity. Outside the atmosphere the sun would appear conspicuously blue, but we live and move and have our being inside the atmosphere, and the color of the illumination outside is only of academic interest. On the meridian the sun gives light that is to all intents and purposes white, but as it declines, the atmosphere steadily filters out the blue and violet, until by the middle of the afternoon the entire blue end of the spectrum is down to about half its previous intensity, while the general luminosity has fallen only about twenty per cent. The general color tone is then distinctly yellowish white, and still later in the day when the sun is only a few degrees from the horizon, the blue contingent is practically wiped out and the light shades off from orange yellow to orange red. Brilliant diffused light, being mixed with considerable sky light, which is noticeably

blue, for the very reason that the setting sun is not, is perceptibly richer in blue rays than average sunlight.

For our purpose, the conspicuous fact about natural light is that it seldom or never verges on the blue or violet, and never is tinged with blue green, green or yellowish-green. Its average tint is slightly yellowish-white, with a tinge of orange late in the day.

A color match made at high noon will not hold when the sun is on the horizon, but memory of exact color value is not much to be trusted, and the knowledge that the tints did match at noon usually convinces the observer at sunset that "the light is poor," any variation being attributed to lack of light rather than to its real cause, change of hue.

As regards artificial lights, generally supposed to fail conspicuously in giving what we are pleased to call "natural" color effects, every one of them, except the enclosed arc, which is strongly bluish, and the Welsbach, which is greenish, can be matched by normal sunlight at some time of the day. Even a Hefner lamp is not redder than a low sun on a hazy day.

The ideal artificial light from a purely utilitarian standpoint should represent average sunlight. So far as artistic results are concerned, from the present canons of human taste, a light weaker in the blue and green is to be preferred. Taste may some day be evolved to a point where a thallium-green illumination will be considered becoming, but we are not there yet.

So far, then, as color is concerned, one can plan for artificial illumination with reasonable freedom of choice. It is by no means clear even that it is always desirable to employ white light for color-matching, unless one can guarantee that the match will be viewed only by white light. An enclosed arc worked with rather small current and untinted globes will distort average or normal color values quite as much as will gaslight. Hence, the importance of enclosing shades which correct color as well as diffuse light.

Classes of Illumination—One may broadly divide illumination into (1) General and (2) Directed. Each class has its own relations to the requirements for quantity and quality, and each may be further subdivided. But so far as methods in the choice of illuminants are concerned, there is an important distinction between light intended to be generally diffused and light intended to facilitate particular operations at particular points. It is in the adaptation of methods to ends that the *finesse* of the art appears.

If by some new invention the energy required to produce one candle-power in illuminants of all classes could be cut down to one-half its present value, the world would be in an uproar over it. But it is well within the truth to say that skilfully treated illumination will effect at least an equivalent saving, or will give vastly better results for the same expenditure of energy. Highly efficient radiants are *per se* very desirable, but if efficiency is gained at the loss of other important qualities, it may be dearly bought. Illumination, visual usefulness, is the thing to be sought. On this basis it has been often maintained with some show of reason that the working unit by which practical lighting should be measured and practical radiants judged is illumination rather than intensity.

Illumination *vs.* Intensity—In favor of using the measured illumination as the criterion by which to judge sources of light, it may properly be said that illumination rather than light intensity is the thing which is practically important. Illumination is the object of artificial lighting, and it is a matter, from this standpoint, of no particular consequence whether the radiants have one or another particular intensity so long as the result is achieved.

On the other hand, I have already shown that the real criterion in artificial lighting is not the illumination as measured in certain conventional ways, but what I have called "visual usefulness;" *i. e.*, the illumination as modified by the way in which the radiants are applied. Moreover, illumination is an extremely difficult thing to measure with precision. There are difficulties enough in ordinary photometric measurements, even when pursued with the aid of the best modern apparatus. The difficulties in the way of measuring illumination in terms of the lux or candle foot at various points in the space that is artificially lighted are tenfold greater. It is photometry with all the conditions against precision, and even with the illuminometer of our confreres Houston and Kennelly, as good an instrument as yet devised for the purpose, the mean error of a single observation is stated by the inventors to be about ten per cent. It and all of the instruments of its class for the purpose of measuring illumination have proved, as a matter of experience, to be both rather slow and rather inaccurate; hence, such measurements are in themselves unsatisfactory as means of passing final judgment upon commercial lighting.

It should further be said that the instruments for measuring illumination as such, seem to be afflicted with peculiarly large personal errors. Some observers, otherwise careful and trustworthy, are unable to get coherent results from them at all, while occasionally one acquires a knack in their use so as to obtain very consistent results, which, however, are more than likely to vary widely from the results obtained by another successful observer.

Aside from this, even were it possible to make measurements of illumination with precision, illumination is not in the last resort the thing which we are really after, which is the power to see; *i. e.*, visual usefulness, and this involves physiological quantities of which it is almost impossible to take physical account.

Moreover, the testing of lighting by illumination, pure and simple, involves the art of placing radiants, and while commercial measurements by illumination might tend to develop this art they will also afford almost unique facilities for meeting the letter but not the spirit of the specifications, facilities which are only too great in the case of even intensity measurements upon commercial illuminants, which are susceptible of determination to a fair degree of accuracy. Hence, in view of all these facts, I believe that, attractive as measurement of illumination, or still better, visual usefulness, may be in theory, in practice it will prove far better to fall back upon intensity measurement on which the illumination measurement must in the last resort depend.

As a rule, I have observed that there is a tendency to favor measurements of illumination chiefly on the part of those engaged in exploiting illuminants that can not satisfactorily stand comparison on the basis of intensity.

We must then, I think, judge commercial illuminants so far as their quantitative relations are concerned by intensity measurements, leaving their qualitative relations—some criteria regarding which have already been suggested—for consideration on their merits.

The Intensity of Illuminants—The fundamental measurement then on which one must base all comparison of methods of artificial illumination is the measurement of the intensity of the radiant.

I have neither time nor disposition here to bore the Institute with any discussion of the technique of photometry. The general methods and apparatus, however, are worth some considerable notice.

To my mind the chief desideratum in dealing with matters of artificial lighting is the settling down of practice on some conventional basis, as regards a standard of light. Working standards may be easily constituted from incandescent lamps, but to obtain a primary standard reproducible with a good degree of precision, and answering reasonable requirements as to color and steadiness is a very different matter. The literature on the subject is large and our Institute committee has added not a little of value to the researches bearing on the subject, but up to date there certainly is not in general use a standard which anywhere nearly meets requirements. The Violle platinum standard, which was a laudable attempt to obtain a standard light which in a general way would fall in line with the centimetre-gramme-second system, may be said to be practically non-existent. It has not proved to be properly reproducible and the experience of most of those who have tried it, is that it is a ticklish and uncomfortable sort of standard to deal with; consequently, its sub-multiple, the *bougie-decimale*, must be regarded as a species of luminous phantasm so far as present practical developments are concerned, and with the *bougie-decimale* should tentatively be classified its derivative, the *lux*. Lux is the conventional name for the fundamental unit of illumination, but so long as it is referred back to the *bougie-decimale*, which is not a practical standard of intensity, it must remain in a species of scientific limbo from which in due time I trust that it may be freed.

As practical standards we have in use

in the scientific and commercial world, the English standard candle, which is the only one having in this country a legal recognized existence; the Hefner-Altneck lamp adopted by the International Congress of 1896, most thoroughly investigated by the Reichsanstalt and scientifically in good repute; the German candle, perhaps, now tending to pass out of use; the French Carcel lamp and the Vernon-Harcourt pentane lamp now developed in a ten-candle-power size.

The relations between these various standards of intensity are only approximately known, each fresh investigation of the subject tending to give a new set of values differing very materially from the last.

The English candle we have all used and, I think, have cordially disliked. It is not very accurately reproducible, although conveniently so. It is not steady to a suitable degree. It is rather small for work with commercial radiants and only fairly good in color. It is, however, the legal standard in this country and so long as it remains so must be treated with a certain degree of respect.

The Hefner-Altneck lamp, on the other hand, is quite accurately reproducible and fairly steady. It is, however, open to two objections so grave that they must inevitably ere long cause its rejection as a general standard. These objections are its very small intensity and its extremely bad color; indeed, its use as a standard involves the problem of color photometry in a somewhat aggravated form. Any one who has often attempted to balance the Hefner-Altneck lamp against an incandescent for example, will realize that although consistent results can by extreme care be obtained the comparison is a distinctly troublesome one and not what one would care to permanently depend upon as the basis of scientific measurement. It is essentially a difficult comparison.

The Carcel lamp is somewhat better in the point of reproducibility and steadiness than the English candle and not as good as the Hefner-Altneck lamp. Its intensity is decidedly more convenient, however, and its color is better than that of the Hefner-Altneck lamp. It can hardly be considered, however, as a standard which is likely to be used in an international way and certainly is without standing in this country.

The Vernon-Harcourt pentane standard —the present legal standard in London— deserves, I think, respectful consideration. It has recently been carefully looked into by the committee of the American Gas Lighting Association with somewhat encouraging results. This committee found a very satisfactory degree of constancy under rather widely varying conditions. The point of greatest interest in its report was that pentane of practically constant quality is commercially obtainable, so that so far as the material consumed goes this standard would seem to be satisfactory as the amyl-acetate one as regards reproducibility. The constancy appears to be satisfactory, and the color and magnitude of the standard are such as to give it a strong claim for consideration. It has not yet been investigated so completely that a final estimate of its desirability may be formed, but I am strongly inclined to the opinion that a standard of as high intensity as this is very desirable and that this particular standard is worthy of very serious consideration.

I have passed by in this brief enumeration the Methven screen which is in considerable and successful use as a secondary standard, but concerning which the consensus of opinion seems to bear out the view that in point of reproducibility and constancy it leaves something to be desired.

Such then is the state of things as regards standards and the unsatisfactory nature of the situation is not open to debate. The most important step to be taken in the reduction of illumination to a practical condition, is the general acceptance of a primary standard even as a tentative matter, so that instead of various investigators working with standards bearing only approximately known ratios with each other, they shall, at least, deal with the difficulties and errors involved in the practical use of a single standard. At present we have results given in candles, decimal candles and Hefner units, and we have to look carefully at the investigator's preface to discover to which of these he has temporarily pinned his faith.

As derived units of illumination we have the lux, in theory based on the decimal candle, and occasionally passing into variants, like the candle meter, using the English candle, or the Hefner unit meter in its turn.

Still apart from these we have the candle foot, which falls in logically enough with our English measurements, but can never be satisfactory as an international standard. Considering the uncertainties at present existing in the fundamental units in the matter of intensity it is small wonder that the derived units are likewise in a bad way. The logical derived unit, which has the greatest importance in a practical way, is the unit of luminous flux, called lumen in the tentative nomenclature of the Congress of 1896. The conception of light out-flowing from a centre and all available light as a quantity based upon this conception, is a most useful one. The total light given by any radiant must evidently be expressed in some such way as this, in order properly to take account of its sometimes very great variations in different directions.

As regards the much-mooted question of a conventional direction of measurement in comparing radiants, it seems to me that the application of a little common sense simplifies the problem wonderfully. If light emitted in all directions from a radiant point may be useful for the purpose of seeing—a proposition which scarcely admits debate—then the total luminous flux is the thing which ought to be measured. If for a particular purpose, under particular circumstances, concentrated light in one direction is desirable, then for that purpose and under those circumstances, light in that direction should properly be measured. It is the case of general illumination on the one hand and directed illumination on the other.

The light from various radiants is distributed in a very diverse fashion. The commonest distribution is that of a more or less flattened ellipsoid, with cups more or less pronounced at either extremity of the axis. Whatever the peculiarities of the distribution, the total light-giving power of the radiant as a whole is settled once for all by its mean spherical value. There is no other method of measurement which gives even an approximate value for the total luminous power which that particular radiant furnishes. In the last resort, this total luminous radiation is the important scientific problem, and hedge it about as we may with certain conditions as to its distribution, in comparing the efficiency of radiants as regards light-giving power, mean spherical intensity is the only ground in common upon which all can stand.

As chairman of the committee of the National Electric Light Association for the rating of incandescent lamps, I have wrestled for the past five years with the intricate and annoying problem of finding for commercial convenience, if possible, some equitable and simple method of applying a common test to radiants differing even so little in their distribution as do incandescent lamps, and after canvassing the whole question and examining a vast amount of data on the subject, after struggling to escape from the details of the somewhat intricate mean spherical measurement, I am compelled to fall back upon it as the court of last resort in matters of illumination.

I shall speak later of some of the annoying practical considerations that have entered into this conclusion. The mean spherical standard, however, is the common basis from which all radiants can fairly meet for a judgment of their total light-giving power and for a comparison of the total luminous energy which they furnish, as related to each other and as related each to its own consumption of kinetic energy. Many objections based upon so-called practical considerations have been raised to this primal rating, but they have been and are uniformly raised by those exploiting illuminants, which can be measured in some other way more advantageously to themselves.

It is perfectly natural from the commercial standpoint for one to desire that his particular radiant should be measured in its direction of maximum candle-power. It reminds me of the early arc lamp salesman who vociferously lauded his particular system before a board of aldermen as furnishing lights of 8,000 candle-power, and when asked for an explanation promptly replied that his lamps were placed at the corners of two intersecting streets and gave 2,000 candle-power up and down each street. If that was not 8,000 candle-power, he would like to be informed why not.

There likewise have been, not infrequently, objections raised to using a can-

dle-power or similar rating at all, or indeed, the falling back upon photometric measurements of any kind, but in all such cases it is entirely safe to assume that a mean spherical measurement of the objector's particular illuminant on a purely photometric basis would disclose very potent reasons for his disinclination for having such a measurement made.

Practical Illuminants—As electrical engineers in dealing with problems of illumination we practically make use of the following classes of illuminants: Open arcs, enclosed arcs and incandescent lamps of various types and efficiencies, to which we must now add the "Nernst" type of lamp.

We may, perhaps, look forward in the future to luminescent lamps of one type or another, but at present these, I regret to say, have no practical bearing upon the art of illumination. These available radiants differ in all the properties which go to make up a useful illuminant, and possess, each of them, vices or virtues more or less important with respect to their adaptability to the solution of various practical problems in artificial lighting. It is perfectly safe to say that no one of them has shown, up to the present, such conspicuous superiority in all particulars as to give any logical reason for adopting it to the exclusion of the others. They vary widely in total power, in intrinsic brilliancy, in steadiness, in color and in efficiency, and all of these properties have to be borne in mind in adapting them to practical business.

General Illumination—By general illumination, I mean such illumination as is ordinarily required for illuminating considerable spaces indoors or out.

General illumination is intended—so far as indoor use is concerned—to give light for the ordinary avocations or amusements which people carry on after nightfall and must be proportioned in intensity and color to the requirements of these conditions.

General illumination outdoors is for similar general purposes, but the requirements for it differ from those for indoor lighting, by reason of the fact that general illumination out of doors is not for the purpose of enabling one to do any particular work, least of all work requiring a strong light, and consequently is usually very much less in amount than general illumination indoors. Moreover, inasmuch as the chief use of illumination out of doors is to enable people to get about conveniently, or at the most to handle rough work expeditiously, its quality in color, brilliancy and even in steadiness, need not come up to the mark which is at once necessary if one attempts to read or to carry on ordinary work by the light in question.

In recent times the tendency has been to use arc lamps for all general illumination outdoors, reserving indoor work for incandescents; a task which it has shared in varying proportions with ordinary gas or gas in some of the modified mantle burners. The chief merits of the arc for outdoor work are cheapness and power.

The old open arc, which until the last few years has done the bulk of general outdoor lighting, possessed the merit of giving at a high efficiency a very powerful light at a moderate price. Its conspicuous demerits were great unsteadiness and intrinsic brilliancy so high that it either had to be shaded or else installed so high above the ground as to be practically out of the field of view except from a distance.

The old open arc was, as all of you know, of two general types: the high voltage arc, *i. e.*, the ordinary type at about fifty volts, and the old low-tension arc of about thirty-five volts pressure between the carbons; the amount of current used in the two being practically inversely to the voltages employed.

The former type was the one which survived the early years of electric lighting, and the so-called 2,000-c.-p. arc, taking about 9.5 amperes, was generally regarded as standard for outdoor work. In point of fact, this open arc was and is the most powerful radiant practically used for exterior illumination. Its great intrinsic brilliancy was always an objection to its use indoors r near the ground, and its distribution of light—said distribution being largely in a narrow zone about forty-five degrees depressed from horizontal—was not such as to answer successfully the requirements of street lighting. The consumption of carbons was rapid and the lamps seldom burned steadily. Indoors the case for such arcs was much worse. They were too bright, too irregular in distribution and far too unsteady for such illumination. From a mistaken notion of economy, also, they were generally installed in too few numbers, each arc replacing about twice the number of gas jets which it ought to have replaced, with the result of giving an unequal illumination with very sharp and dense shadows that proved extremely annoying to the eyes, and the visual usefulness of which was extremely limited.

With the growth of constant-potential circuits special open arc lamps were devised, which overcame in a measure certain of these difficulties, particularly the unsteadiness. The difficulties of too great brilliancy and bad distribution remained, however, with the open arc even in this improved form.

Abroad it has been and is the practice to use two and sometimes three constant-potential open arcs in series across the ordinary lighting mains, and owing to the fact that carbons of a very high quality are available in Europe at a low price, in point of steadiness the Continental type of open arc has generally proved very satisfactory; while the installation of two or three in series so greatly increases the output of light for a given expenditure of energy when working on a constant-potential circuit that one can afford to enclose the arcs by dense diffusing globes, which almost entirely obviates the difficulty of too great brilliancy.

In this country, as you all know, the recent tendency has been entirely toward the enclosed arc. The great economy of carbons and of labor, together with the steadiness of the light and the improvement of the distribution by the lengthened arc and by the diffusing inner globe, have operated to bring such arc lamps into constantly increasing use both indoors and out. It must be said, however, that enclosed arcs have one fault which may become and often is very serious, *i. e.*, a tendency toward an exaggerated bluish white or even violet hue, which makes the illumination derived average as bad in point of color as in any known artificial illuminant.

Dr. Bell added to the printed paper a number of remarks concerning outdoor lighting in general. He said that for most outdoor work the color of the arc is not objectionable. The enclosed alternating-current arc distributes its light much better than the open arc, although its intrinsic efficiency is less. The old so-called 2,000-candle-power arc was a very powerful and satisfactory apparatus for street lighting. His own experience was that a seven and one-half ampere alternating-current enclosed arc may replace lamps of this type with general satisfaction.

He spoke of attempts to obtain a whiter light by forcing alternating-current arcs, as, for example, by using smaller carbons, so that the current density at the arc might be greater, causing higher temperature.

In no case must the source of light be placed where the eye can see it. Dr. Bell spoke at some length of the futility of building lamps for condensed radiation in one direction, when by appropriate and very simple reflectors effects much more powerful than those that could be obtained from such structures might easily be had. He showed a table giving results of photometer measurements on the condensation due to reflectors of various types variously applied.

The next paper was that by Mr. W. D'A. Ryan, which appears in full below:

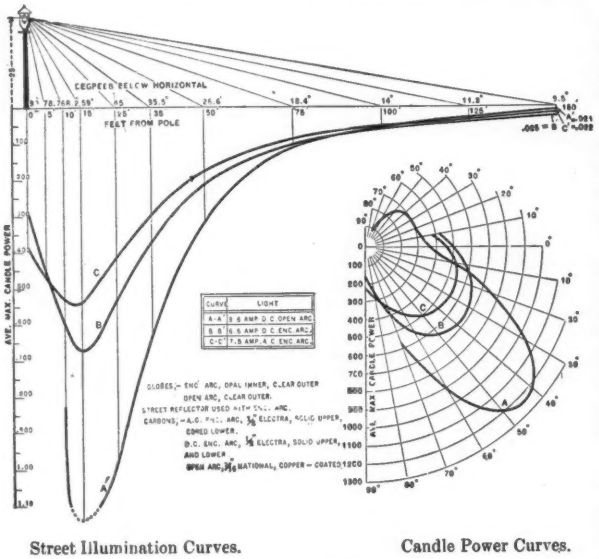
STREET ILLUMINATION AND UNITS OF LIGHT.

BY W. D'A. RYAN.

Photometry—In order to make photometric comparisons of open and enclosed arcs I have found it necessary to work as far as possible with fixed conditions such as current, voltage, and position of arc. The widely different results of various investigators are in part due to insufficient attention to these essential points, particularly the latter. A photometer with a reasonably long bar is also indispensable. This should be provided with an adjustable revolving sector disc by which the light from the arc can be reduced so that all settings can be made in the most accurate part of the scale. This arrangement permits working with a single standard and with light of low intensity which de-

creases the error introduced by color difference. A rotating crane is required for elevating and depressing the lamps in order to measure the light from different angles in the vertical plane.

A Bunsen photometer as described can be operated by three observers, but I have found four more satisfactory; one devotes his time entirely to making settings of the screen, the second maintains the current and voltage at the proper values, the third notes the position of the arc, and the fourth records the readings taken when the fixed quantities are correct. After working together for a few days such a complement can reproduce the average characteristics of light distribution of arc lamps to within five or six per cent of the mean which, for arc lamp photometry, is considered very satisfactory.


DEGREES BELOW HORIZONTAL
FEET FROM POLE
AVE. MAX. CANDLE POWER
CANDLE POWER
CURVE LIGHT
A-A 9.6 AMP D.C. OPEN ARC
B-B 6.6 AMP D.C. ENC. ARC
C-C 7.5 AMP A.C. ENC. ARC
GLOBES,- ENC. ARC, OPAL INNER, CLEAR OUTER
OPEN ARC, CLEAR OUTER.
STREET REFLECTOR USED WITH ENCL. ARC.
CARBONS,- A.C. ENCL. ARC, 1/8" ELECTRA, SOLID UPPER, CORED LOWER.
D.C. ENC. ARC, 1/8" ELECTRA, SOLID UPPER, AND LOWER
OPEN ARC, 7/32" NATIONAL, COPPER - COATED

Street Illumination Curves. Candle Power Curves.

FIG. 1.—STREET ILLUMINATION AND CANDLE-POWER CURVES.

Candle-Power Curves—The curves in Fig. 1 were obtained by the method described. To render the curves of commercial value the tests were carried on with lamps equipped as they ordinarily would be for street lighting, that is to say, the open arc lamp was trimmed with seven-sixteenth-inch National carbons and was provided with a clear globe.

The enclosed arc lamps were trimmed with high-grade carbons and were provided with opal enclosing and clear outer globes and street reflectors. All lamps were adjusted so as to consume approximately equal watts at the arc.

First confining our attention to the direct-current lamps, curves A and B, we will observe that the open arc lamp gives a greater maximum candle-power (which, of course, is not by any means a measure of its usefulness). The enclosed arc lamp gives a stronger light through the most useful angles of from say three degrees to ten degrees below the horizontal and from the shape of the curves it is self-evident that the distribution from the latter is more uniform.

Illumination Curves—We are not, however, particularly interested in the candle-power of the lamps. We desire principally an even illumination along the street surface, and we wish mainly to project the light as far from the source as possible.

To make this comparison it is therefore necessary to convert the "candle-power curves" into "illumination curves" giving the candle feet along the ground on surfaces normal to the rays of light.

The illumination curves in Fig. 2 are plotted for lamps twenty-five feet above the ground and at intervals of 300 feet. By introducing the element of distance we find that the strongest light received on the ground from the open arc is not projected at an angle of forty-five degrees as indicated by the candle-power curves, but falls at an angle of about sixty degrees below the horizontal, illuminating the ground brilliantly at a distance of about fifteen feet from the pole, thus showing that in order to properly compare illumination of different lamps we must look to the surface illumination curves rather than the candle-power curves, as previously stated.

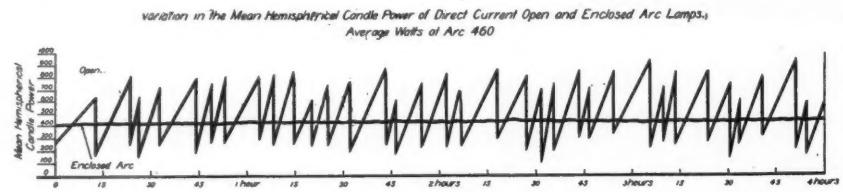


FIG. 2.—VARIATION IN CANDLE-POWER.

Further analyzing the curves it will be observed that the illumination of objects on the street surface from the open arc lamp is brighter up to a distance of about 100 feet from the source. Beyond this the light from the enclosed arc lamp is the strongest, and at 150 feet it exceeds the open arc by considerable, and this is made still more effective by the absence of strong light in the immediate vicinity of the lamp. This advantage is so obvious that further comment seems unnecessary.

Comparisons so far have been confined to fixed conditions with respect to current, voltage and the position of the arc.

We have next to consider the variations caused by the wandering of the arc, variations of potential between picking up and feeding points, fluctuations due to drafts of wind, non-homogeneity of carbons and other changes introduced by the inherent peculiarities of the different lamps.

Varying Arc—Open arc lamps ordinarily pick up at about forty-five volts and feed normally at about fifty. The light projected in any direction is approximately proportionate to the amount of crater area visible from any point in that direction, and the amount of crater area visible varies greatly with the small change in the length of the arc introduced by a difference of five volts.

Where lamps have been installed for a considerable period and have not received proper attention, the voltage variation may greatly exceed the normal limits. The lamp is then said to be working between a sluggish feed and the hissing point, and as the arc feeds on an average cycle of about ten minutes, varying irregularly between five and fifteen minutes, the candle-power and illumination shown in Figs. 1 and 2 represent only instantaneous values which occur at very irregular intervals.

The enclosed arc lamp is particularly free from this variation. The arc is about three-eighths inch in length and the lamp feeds in about four-hour cycles varying irregularly between three and five hours, and the feed is an instantaneous drop and pick up to the original position. There is, however, a rise of voltage due to the heating of the shunt coils which may amount to ten or fifteen volts. This is a gradual rise, taking place during two or three hours, and is not noticeable as a variation to the casual observer. It is objectionable, however, for other occasions. In some lamps this variation is controlled by what is called a "compensating winding" which automatically adjusts the relation between the shunt and series coils as the lamp heats up.

For such lamps we may say that the mean hemispherical light is practically constant as the voltage at the arc does not materially change. Thermostats have also been employed to accomplish the same results, but they have not proved entirely satisfactory, and in some localities they require a summer and a winter adjustment.

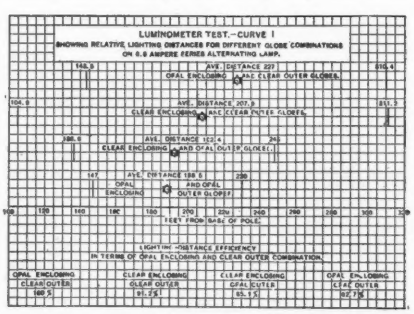

LUMINOMETER TEST.—CURVE I
SHOWING RELATIVE LIGHTING DISTANCES FOR DIFFERENT GLOBE COMBINATIONS ON 6.6 AMPERE FERREE ALTERNATING LAMP.
AVE. DISTANCE 227
OPAL ENCLOSING AND CLEAR OUTER GLOBES.
AVE. DISTANCE 207.3
CLEAR ENCLOSING AND CLEAR OUTER GLOBES.
AVE. DISTANCE 122.4
CLEAR ENCLOSING AND OPAL OUTER GLOBES.
AVE. DISTANCE 186.5
OPAL ENCLOSING AND OPAL OUTER GLOBES.
FEET FROM BASE OF POLE.
LIGHTING-DISTANCE EFFICIENCY
IN TERMS OF OPAL ENCLOSING AND CLEAR OUTER COMBINATION.
OPAL ENCLOSING CLEAR OUTER
CLEAR ENCLOSING CLEAR OUTER
OPAL ENCLOSING OPAL OUTER
CLEAR ENCLOSING CLEAR OUTER

FIG. 3.—LUMINOMETER TEST.

Wandering Arc—The second variation of importance in open arcs is caused by wandering of the arc, due primarily to the non-homogeneity of the cheap grade of solid carbons usually employed.

(Concluded next week.)

Electrochemical and Electrometallurgical Industry—V.

ARTICLE V: PROGRESS IN THE REMAINING COUNTRIES OF EUROPE.

By John B. C. Kershaw.

(Concluded.)

INTRODUCTION.

IN Articles II, III and IV of this series, the progress of industrial electrochemistry and electrometallurgy in the United Kingdom, France and Germany has been dealt with. In this article, which closes the series, the position of these new industries in Switzerland, Russia, Austria, Italy, Spain, Norway and Sweden will be described. These countries, with the single exception of Russia, are well provided with water power, and in Switzerland and Norway especially the conditions are favorable for the development of electrical power, at exceptionally low cost. At Sarpsfos, in Norway, power is sold to the two carbide works for $11.50 per electrical horse-power year, and at Hagnek, in Switzerland, the electrical horse-power year is sold for $12.

In Italy, Austria and Spain, the average outlay upon water-power installations has been higher than in Switzerland and Norway, but in spite of this the ultimate cost of the electrical horse-power year compares favorably with the cost of steam power in the United Kingdom or in Germany.

To take one example—that of the large power installation of Paderna, near Milan—in Italy—where 13,000 horse-power has been developed by the erection of a dam 500 feet in length on the River Adda, and a head of water of seventy-six feet obtained for power generation. The hydraulic engineering work in connection with this scheme has been heavy, and the charge to consumers in this neighborhood is stated to be $28.80 per electrical horse-power year. This may seem high compared with the cost of the electrical horse-power year in Norway and Switzerland, but it is much lower than the cost of steam power in Italy, which has to import most of the coal used in her industries from Germany or the United Kingdom. In Spain and Austria the conditions are somewhat similar to those obtaining in Italy, but Austria possesses coal fields of some extent, and her proximity to Germany enables her to supplement her home supplies of coal more cheaply than Spain or Italy. It is thus seen that in Switzerland, Norway, Austria, Italy and Spain the conditions as regards supply of power are favorable for the development of electrochemical or electrometallurgical industries—and it is in these countries that the most striking advances will probably be witnessed during the next twenty-five years.

That the growth of these new industries in the five countries named has not been very marked up to the present time is due to several causes, chief of which are lack of capital and enterprise, and lack of technical knowledge. These deficiencies have tended toward concentration of the industries in the countries in which they were founded, but this position of affairs will not continue.

Capital and knowledge show an increasing tendency to flow wherever the conditions are favorable to profitable investment, and now that falling water has proved to be a satisfactory and cheap substitute for coal, the industrial rise of Spain, Switzerland, Italy and Norway is assured. As pointed out in Article IV this progress of countries which have been hitherto regarded as agricultural in character, will have a notable effect upon the manufacturing populations of Europe, and it is quite within the bounds of possibility that the chemical and metallurgical industries in the year 2001 will be found most highly developed in those countries which to-day stand last in the classification adopted in these articles.

AUSTRIA.

The electrochemical and electrometallurgical industries of Austria are few in number, and no very marked success has yet been obtained with these new methods and processes of manufacture.

At Hallein, the Kellner-Partington Paper Pulp Company has a cellulose and wood pulp factory where twenty tons of bleached pulp is produced per day. Power for driving this factory is derived from the Salzbach, and electrolyzed salt solutions are used for bleaching the pulp in place of bleaching powder. The Kellner electrolytic cell is used at this factory, but though I have more than once applied for details of the installation, I am still unable to give any figures showing the size or efficiency of the electrolytic plant at this place. The power developed from the Salzbach, at Hallein, is said to amount to 2,500 horse-power, but the greater portion of this will no doubt be utilized for driving the pulping machinery.

At Golling, near Hallein, a further 4,500 horse-power is stated to have been developed from the Salzbach, and here the "Consortium für Electrochemische Industrien," a Vienna company, has been working electrolytic processes for the production of alkalies, chlorates and bleach since 1896, with, I believe, indifferent success. The processes worked are patented by Dr. C. Kellner, of Vienna, but again no details are available for publication; and attempts by myself to obtain direct information as to the progress made—from Dr. Kellner and others—have never been successful. In 1898 the company was reorganized and the capital increased to $1,480,000, but since that date no information has been published concerning this company or its factory at Golling. The obvious inference from this lack of information is that the works have been unsuccessful.

At Jaice, in Bosnia, the "Bosnische Elektricitäts Aktien Gesellschaft" has developed 9,200 horse-power from the River Pliva, and the manufacture of calcium carbide and alkalies has been carried on at this spot since early in 1900. The fall in calcium carbide values has, of course, seriously affected the prospects of this fine power installation, and although a plant of 8,000 horse-power had been erected for carbide production, at the present moment it is doubtful if any of the furnaces are at work. The alkali works were planned for the utilization of 1,200 horse-power, and the Kellner process is understood to have been in use; but, as in the case of the works at Golling, no reliable information can be obtained concerning the progress of the undertaking.

At Lend-Gastein a fall of sixty-three metres (206 feet) on the River Achen has been developed for power generation by the Neuhausen Aluminium Company, and generating plant equal to 5,000 horse-power has been installed. The original plan was to apply this power to aluminum production, but since calcium carbide is being manufactured at Rheinfelden by the same company in place of aluminum, it is

doubtful whether the demand for the new metal yet justifies the commencement of manufacture at Lend-Gastein. This new plant raises the power available for the requirements of the Neuhausen company to 14,000 horse-power, and if all this were applied to aluminum production, the output of this company would exceed that of the Pittsburgh company. Should the price of calcium carbide rise, the plant at Lend-Gastein will probably be devoted to its manufacture.

At Meran, in the Austrian Tyrol, the "Acetylen Gas Gesellschaft," of Vienna, has erected a carbide works, and has 2,400 horse-power available for its manufacture. Although the electrical horse-power year at this place only costs $10, the Meran factory has been seriously affected by the fall in carbide values, and, according to the latest information, portion of the power available is now being devoted to the manufacture of ferrochrome and similar alloys.

At Aussig, the "Oest-Verein für Chemische Production" is working a "Bell" or gravity process for the manufacture of alkalies and bleach with success, and recently it was stated by Hausserman that with 600 horse-power an output of eight tons per day had been obtained.

Small copper refinery works are operating at Brixlegg and at Wittkowitz, in Silesia, while at Prague there is a small carborundum factory operating the Acheson process. The Hoepfner electrolytic process for zinc extraction was at one time worked by the "Oest. Soda Fabrik," at Hruschau, but I believe success did not attend this installation, and that the trials of the process have been suspended.

Carbide works have also been built in Austria, at Matrei, Lobkowitz, Sebenico and Paternion, but no details of these are available for publication, and the probability is that all of them are temporarily shut down, as a result of the depression in the carbide industry.

ITALY.

The manufacture of calcium carbide is the only electrometallurgical industry which has developed to any extent in Italy. Carbide factories have been built and operated at Tarni, Foligno, St. Martino, Milan, St. Marcel, Salisano, Lugano and Rome, but it is doubtful whether all of these have been producing carbide since the collapse in the industry.

The largest of these Italian carbide works is that of the "Societa Italiana Carburo di Calcio," at Collestatle, near Terni, where 9,000 horse-power is reported to be available for the manufacture. A head of 143 metres (469 feet) has been obtained at this spot by extensive hydraulic engineering works. The water is taken from the River Velino, and six 1,500-horse-power turbines, direct-coupled to monophase dynamos of equivalent size, are in use. Heroult type of carbide furnaces is employed.

A second large carbide works for the same company is being erected at Papigno, near Terni, where 18,000 horse-power, also drawn from the River Velino, is to be developed for industrial use. At St. Marcel the "Societa Piedmontese Carburo di Calcio" has 3,000 horse-power available for carbide production; while at Milan 1,000 kilowatts from the Paderna generating station has been utilized for the same manufacture. As proof of the difficulties caused by the economic crisis in the industry it may be noted that the "Societa Forni Elettrici," of Rome, can not pay any dividend for the past year's operations.

Electrometallurgists in Italy have, in fact, built carbide works *far in excess of the present European demand,* and it will be some years before the Italian industry is established on a firm financial basis.

Several companies have been promoted in Italy for the production of alkalies and chlorine compounds by electrolytic processes, but, so far as I am aware, none of the factories planned is yet in operation.

The "Societa Italiana Elettrochimica Volta" is building a factory at Bussi, where 2,800 horse-power has been developed; and a second company, promoted by German, Swiss and Italian capitalists, is erecting a works near Bellinzona, where 18,000 horse-power is reported to be available for industrial use. A French process is to be used in the latter works. A third company, the "Societe Italienne d'Electrochemie," was also floated by some electrical firms in Turin, in 1899, with a capital of $800,000, but no information concerning the locality of its operations or the process to be used has yet come under my observation.

At Turgi the "Gesellschaft für Elektrochemische Industrie" is reported to be using 600 horse-power in the manufacture of chlorates by electrolysis, but no details of the process employed are available for publication.

One of the most interesting Italian developments in electrometallurgy is the proposal to use the electric furnace for smelting iron ores, and for the direct production of steel in one operation. The process patented by Captain Stassano was tried near Rome, upon a small industrial scale, in 1899-1900, and the results obtained in the preliminary trials are said to have justified the erection of a large plant at Darfo, in northern Italy, where 1,500 horse-power is available. An output of 4,000 tons steel per annum is expected. If the steel produced in this way can compete in price and quality with that manufactured by the older methods, the Stassano process is likely to extend rapidly in Italy.

At Rome and Milan hydrogen and oxygen gases are produced upon an industrial scale by electrolysis of dilute solutions of caustic alkali. The gases obtained in this way are compressed and sold in steel cylinders of the usual type. They find employment in many of the minor industries, and the cost of production is considerably less than by any of the methods previously used for manufacturing these gases on a commercial basis.

NORWAY AND SWEDEN.

The most successful electrochemical industry yet developed in Norway and Sweden is that of the manufacture of chlorates.

The "Superfosfat Fabriks Aktiebolag," of Stockholm, started the industry at Mansboe in 1894 with 1,700 horse-power, and 4,500 horse-power is now available for the manufacture at this place. The Carlsen cell and process are used at Mansboe, but the principle is the same in all electrolytic processes for chlorate production.

A second chlorate factory has recently been started at Alby, where 12,000 horse-power can be developed from the Ljungan waterfall, but no details of the process in use have come into my hands.

At the famous Sarpsfos Fall, in Norway, two companies have taken in hand the development of the water power, and already generating machinery equal to 10,000 horse-power has been installed. The Kellner-Partington Paper Pulp Company has erected a wood-pulp factory and a carbide factory on its side of the Fall, and the whole of the power requirements of these two factories are supplied from the generating plant at the foot of the Fall. The Schuckert Company, of Nuremberg, has been responsible for the power developments on the other side of the Fall, and generating plant and machinery equivalent to 3,000 horse-power for carbide production are now in use.

The two subcompanies owning the carbide factories at this spot are named the "Aktieselkabet Hafslund" and the "Aktieselskabet Karbid-Industrie." In 1900 the latter company produced 1,500 tons carbide.

The Kellner-Partington company uses some portion of the power available at Sarpsfos for production of bleaching solutions by electrolysis, these solutions being used in the manufacture of the finer qualities of wood pulp.

At Trollhatten, in Sweden, another large water power is being developed by the "Trollhatten Elektriska Kraft Aktiebolag" for industrial use, and it is proposed to erect electric smelting furnaces on the Laval principle at this spot. Up to the present only calcium carbide has been manufactured, and in 1900 an output of 1,500 tons is reported to have been attained.

Experiments in the reduction of iron ores and the direct production of steel are, however, proceeding, and in time Trollhatten may become an important centre of electrometallurgical industry.

Other carbide factories exist at Orebro (3,000 horse-power), Meraker (1,500 horse-power), Kinservik (3,000 horse-power) and at Brottfors, but it is doubtful if any one of these has been working continuously during the last twelve months.

At Stjernfors a wood-pulp factory is reported to have operated a modified form of the Hermite cell for hypochlorite production since 1894, the solutions being used for bleaching the cellulose produced. The installation is a small one, and only seventy-five horse-power is said to be utilized.

The development of power on a very large scale is now proceeding at the Askim Falls, on the River Glommen, fifty miles from Christiania, where 45,000 horse-power is available. Portion of the power developed is to be transmitted to Christiania, but the remainder is to be utilized in electrochemical and electrometallurgical industries near the Falls. The Schuckert Company is cooperating with the Glommen Saw Mills Company in this development, and the first unit of plant is expected to be operating in 1902.

RUSSIA.

Copper refining is carried on in Russia by the electrolytic method at Bogoslousk, in the Ural Mountains; at Kedabeg, in the Caucasus Mountains, and at Moscow. The two first mentioned refineries are under the control of Siemens & Halske, of Berlin, and are worked in conjunction with copper ore mining and smelting works. The third refinery is owned by Nikolajeff, and is operated by steam power. It produced only 350 tons refined copper in 1900.

The electrolytic alkali industry is represented in Russia by three factories, all situated in the southeastern oil-bearing districts, where large quantities of caustic alkali are used in the oil-refining works. These three alkali factories all use steam power.

At Zombkowici the "Akcyjne Fowarzystons Elektrycznon" has a plant of 1,200 horse-power capacity at work, using the Bitterfeld process, and in 1900 3,800 tons of caustic alkali and bleach were produced.

At Donetz Lubimoff-Solvay & Company, which control the Solvay ammonia-soda manufacture in Russia, are erecting a 1,500-horse-power plant for operation of the Solvay mercury cell, an improved form of the Castner cell. This cell has been working for some months at Jemeppe, in Belgium, and is said to give highly satisfactory results. At Slaviansk the "Elektron" company's process is utilized, the works at this place having been built by a subcompany, promoted by the Griesheim firm, in 1899. The capital of this subcompany is reported to be $1,485,000, and a plant of 1,000 horse-power capacity was originally built.

Carbide manufacture is carried on only at one place, this position of the industry being due to lack of water power in the western and southern portions of the Russian Empire.

The carbide factory is situated at the Hamekoski Falls, near St. Petersburg, and 2,000 horse-power is reported to be available. The financial results obtained in other European countries in this manufacture have been so bad, and the industry is so over-capitalized that Russian financiers may congratulate themselves there has been little inducement to develop this industry in their own country.

SPAIN.

The manufacture of carbide and of caustic alkali are the only industries actually carried on in Spain at the present moment by electric power. The carbide factory is owned by the "Societa Espanola Carburos Metalicos," and is situated at Berga, where 4,000 horse-power is reported to be available for the manufacture. At Flix, on the River Ebro, 3,000 horse-power has been developed by the "Sociedad Electroquimica de Flix," a subcompany promoted by the Gresheim firm, and alkalies and chlorine products are now being produced there by the "Elektron" process.

It is not known what proportion of the total power available is actually employed at present in these manufactures.

SWITZERLAND.

The manufacture of chlorate by the electrolytic method is the oldest Swiss electrochemical industry. The pioneer factory in this industry was established by Messrs. Gall & Montlaur, of Paris, at Villers-sur Hermes, in the year 1889, and the results being satisfactory the plant was transferred to Valorbes in 1891. The Valorbes factory is still in operation, the "Societe d'Electrochimie," of Paris, owning this works, and those at St. Michel, erected three years later. (See Article III.) At Valorbes 3,000 horse-power is available for the manufacture, and the capital outlay for development has only amounted to $52,000, or $17.30 per horse-power obtained at the turbine shaft.

The aluminum industry in Switzerland also dates from 1889, in which year the factory at Neuhausen was working the Heroult process on an industrial scale. Full details of the growth of this industry at Neuhausen are given in Article IV.

The manufacture of carbide has been carried on at several places in Switzerland, among which Neuhausen, Vernayaz, Lauterbach, Vernier, Wynau, Hagnek, Thusis, Gampel, and Berne may be named.

The slump in this industry, due to the fall of prices in 1900, has caused the majority of these factories to suspend operations, and in some instances, as at Wynau, liquidation of the company has resulted. At the moment, therefore, there are many thousands of horse-power in Switzerland awaiting profitable employment, and the inventor of any new electrometallurgical process which promised to be successful should have no difficulty in obtaining practical trial of his invention in the land of ice and snow.

Alkalies and chlorine products are produced at only two works in Switzerland by the electrolytic method. At Chevres, near Geneva, the "Societe Anonyme Suisse de l'Industrie Electrochimique Volta" operates the Outhenin-Chalandre process with 1,000 horse-power. This process is a diaphragm process, and in 1900 2,000 tons of alkali and bleach were produced by it at the Chevres works.

The second works is at Monthey-en-Valais, where the "Societe des Usines de Produits Chimiques" operates the *"Elektron"* process with 1,500 horse-power. In 1900 3,500 tons of the two products were produced at this works, which is the only one using the "Elektron" process not under the control of the parent firm.

At Orbe, a tannery, producing 300 skins per week, is said to be operating the Groth process, but reliable information upon this industry is lacking.

CONCLUSION.

The review of the present position of the electrochemical and electrometallurgical industries in Europe and America, given in this and the preceding four articles, shows a remarkable record of progress for the ten years, 1891-1901.

As pointed out in the ELECTRICAL REVIEW'S leading article of September 28, 1901, these new industries may at no very distant date represent a greater aggregate of electrical horse-power than all the lighting and traction stations now in existence.

An estimate of the power utilized in 1900 gave an aggregate of 215,000 horse-power,* and this total will undoubtedly grow with each succeeding year. Speculation, over-capitalization and over-production in particular industries must, however, be guarded against. The financial collapse in the calcium carbide industry, due to the company-promoting "boom" of 1898 and 1899, was foreseen by many, and in most cases those who have lost money in carbide or acetylene companies have only themselves to blame. To cover Europe with works for manufacture of a compound for which there were only a limited demand and sale was the most certain way to court disaster.

The law of local supply and demand, in spite of the improved facilities for the transit of raw materials and finished goods, is still the chief factor in determining the success of any industrial venture.

Electrochemical and electrometallurgical works are no exception to this general rule, and they will be most successful financially when careful attention has been given to local conditions, and when the chief market for the products made is to be found in the immediate vicinity of the works and power installation.

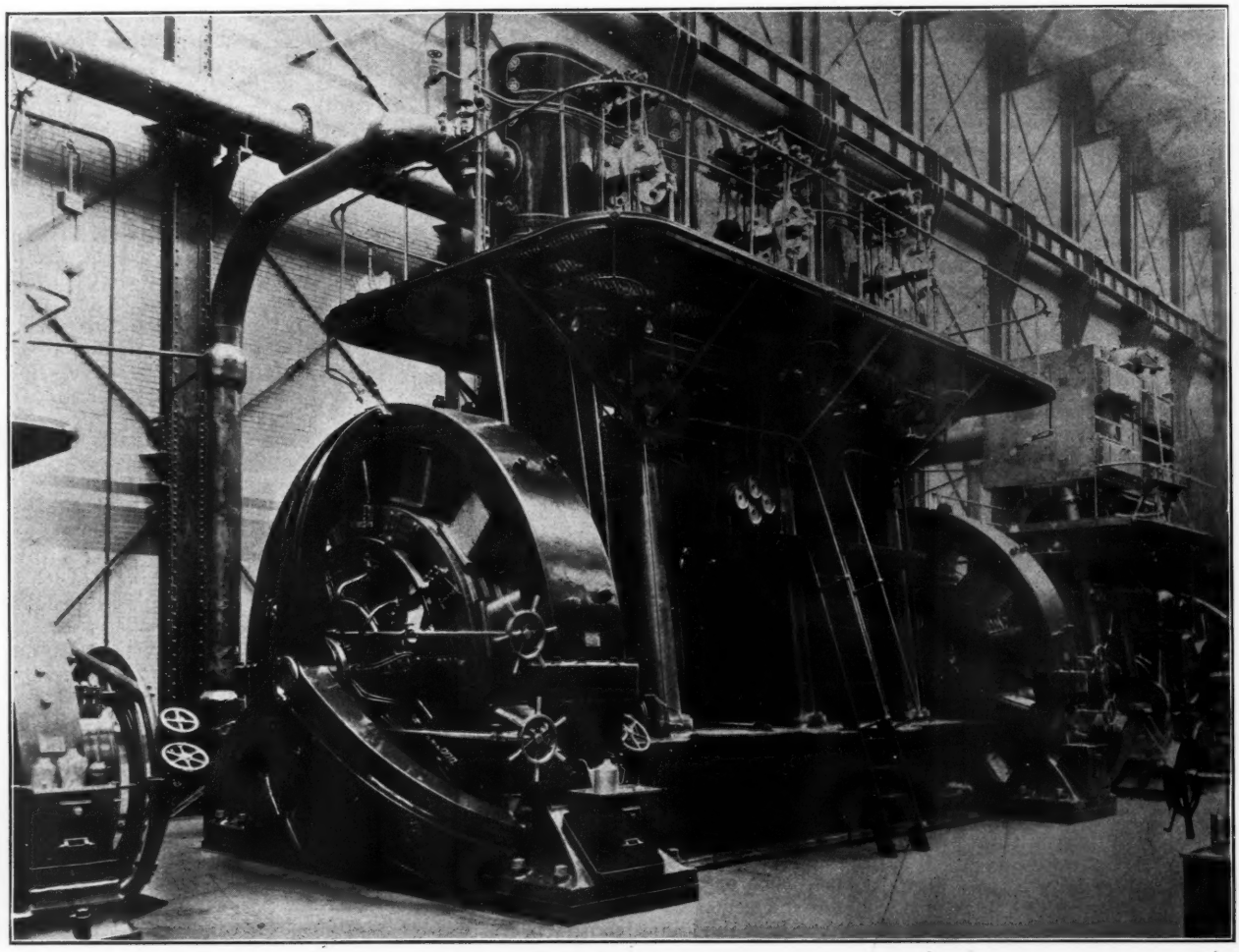
*See the (London) *Electrician*, January 11, 1901.

The Lighting System of the Chicago Edison Company.

A Study of the Plant and Methods of One of the Largest Electric Lighting Supply Companies in the World.

CHICAGO is built on a level plain lying to the west and south of Lake Michigan, and its corporate limits include an extension of twenty-six miles from north to south and more than ten miles at the widest point of the irregular parallelogram which forms the city's plot. In this area is included over 200 square miles of territory, in which there are several subordinate condensations of population, while the total population of the urban district is estimated to be at present somewhat in excess of 2,000,000. The city is divided into three parts by the two branches of the Chicago River, the district included immediately south of the main river and east of the southern branch—between that and Lake Michigan—being the business centre and the most closely built up district. Here, in about a square mile of territory, is situated a considerable preponderance of the electric lighting load.

The Chicago Edison Company and its affiliated corporation, the Commonwealth Electric Company, between them supply light and power to the entire district included within the city limits of Chicago, the operations of the Edison company proper being confined to a district including the business centre and thickly built portion of the city, as is indicated by the accompanying map. Within this district electric current for lighting and power purposes is supplied from underground mains as direct current. Outside of this district the supply is at present alternating current at sixty cycles. The outgrowth of the consolidation of numerous suburban towns formerly surrounding the old city of Chicago within the municipal limits of the city, resulting eventually in a somewhat similar consolidation of the various electric lighting interests of the absorbed territory and bringing under one management a considerable number of plants of different character, presented an attractive but nevertheless difficult problem in the joint operation of these systems. It was decided, on account of local conditions which will be described more fully below, that direct current should be used throughout the central district where it had originally been installed in the early plant of the Chicago Edison Company; and for the time being, at least, alternating current would be used



A THREE-WIRE, 800-K.-W. UNIT IN THE HARRISON STREET STATION OF THE CHICAGO EDISON COMPANY.

General Arrangement of Stations & Sub-stations
OF THE
CENTRAL STATION COMPANIES.
Nov. 22, 1901.

MAP SHOWING THE GENERAL ARRANGEMENT OF STATIONS, SUBSTATIONS AND CIRCUITS OF THE CHICAGO EDISON COMPANY.

in the outlying districts of the city with plants properly connected and adapted to operate polyphase motors where a demand for power was exhibited. At the same time it came to be realized that the extent and continual growth of the current supply from the direct-current mains would necessitate another system of generation and distribution than that originally installed. It was decided, therefore, to adopt a system of generation using polyphase current, either generated directly at 9,000 volts or at other pressures and stepped up to this voltage, and that twenty-five cycles should be the standard frequency of the generating and power distributing supply system. A great station was built on the south branch of the Chicago River, situated about 3,000 feet from the approximate centre of distribution in the business part of the city, and in this was installed more than 20,000 horse-power in engine-driven generators. At a point near the centre of distribution a large storage battery was installed, and at numerous points connected with the direct-current distribution network substations were erected for the reception and conversion of the alternating current generated in the large station at Harrison street. For the present this installation may be regarded as the central generating plant of the company, but there are in addition several others in the outlying districts, as will be described in detail below.

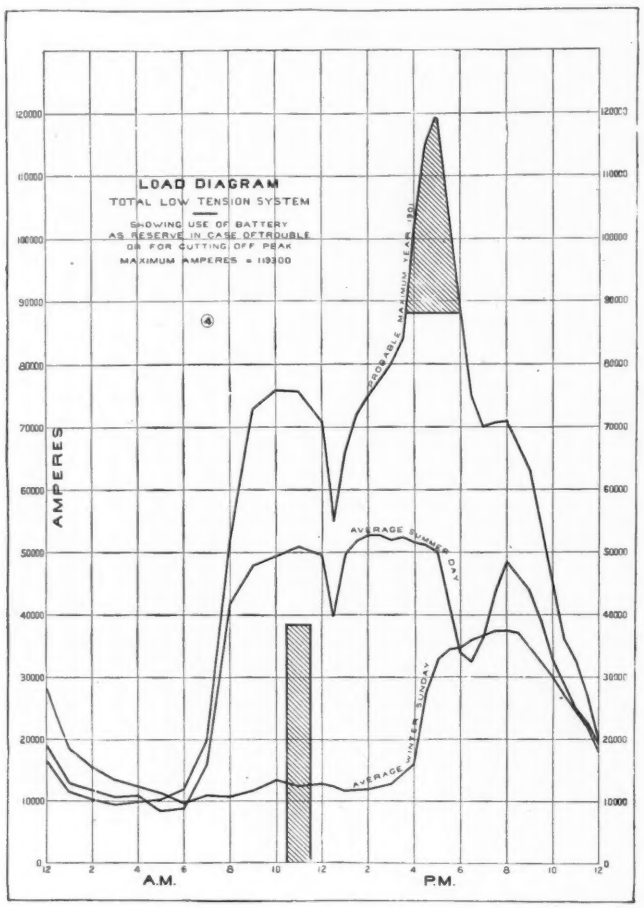
THE HARRISON STREET STATION.

The Harrison street station is situated on the west side of the south branch of the Chicago River, at the intersection of Harrison street, and consists of a brick building admirably situated with respect to coal delivery either by boat from the river or by rail from adjacent tracks.

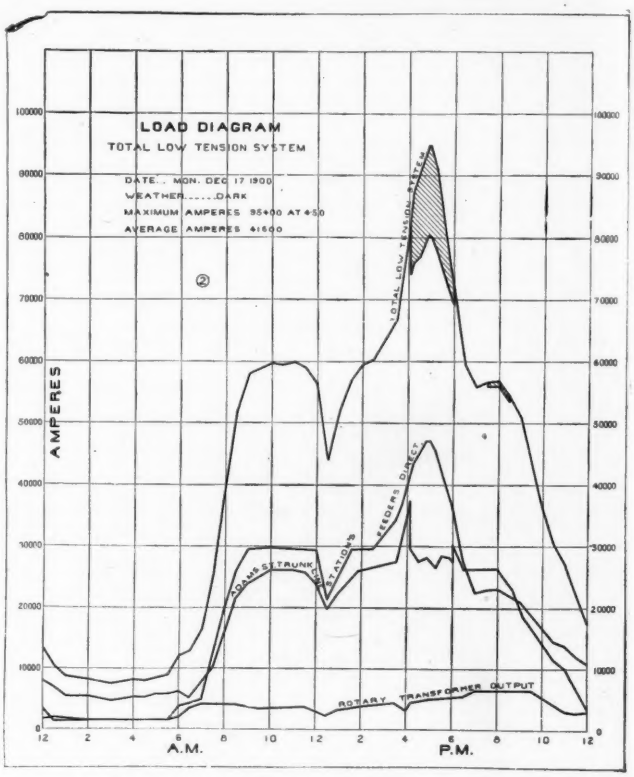
The boilers are twenty-four in number, of the Heine water-tube type, seven of them being rated at 500 horse-power and the remaining seventeen at 570 horse-power each. These boilers are equipped with chain grates of the automatic stoking pattern made by the Babcock & Wilcox Company, the fuel used being Illinois screenings. Overhead, above the boilers, is situated a series of steel coal pockets having a capacity of 3,000 tons of this fuel, or enough for about ten days' operation of the station under normal condition. The coal is received either by boat at one end of the station or by rail at the other, and is taken by conveyors to these overhead storage bins, whence it is fed directly to the automatic stokers by means of chutes. At the landward end of the station a conveyor, made by the Robins Conveying Belt Company, receives coal from freight cars and delivers it to the bucket conveyor which carries it to the storage bins. This belt conveyor is mounted on rails and is long enough to take care of three cars at once. The conveyor is operated by an electric motor of fifteen horse-power.

The hot gases from the boilers are taken in steel breechings to four enormous steel smokestacks, each being twelve feet in diameter and 180 feet high. The engine room is of generous dimensions and is notable on account of the great height of its ceiling. The room is spanned by an electric traveling crane and at its eastern end is mounted the switchboard on two galleries on different levels, as may clearly be seen in the illustrations. In this engine room the generating units are arranged in two rows, the western end being occupied by two gigantic units which are described somewhat at length below. The generating equipment consists of the following apparatus:

Two double-current and two direct-current units, each consisting of two 200-kilowatt generators, coupled to the two ends of a Southwark Foundry and Machine Company's triple-expansion, vertical marine-type engine, running at 150 revo-

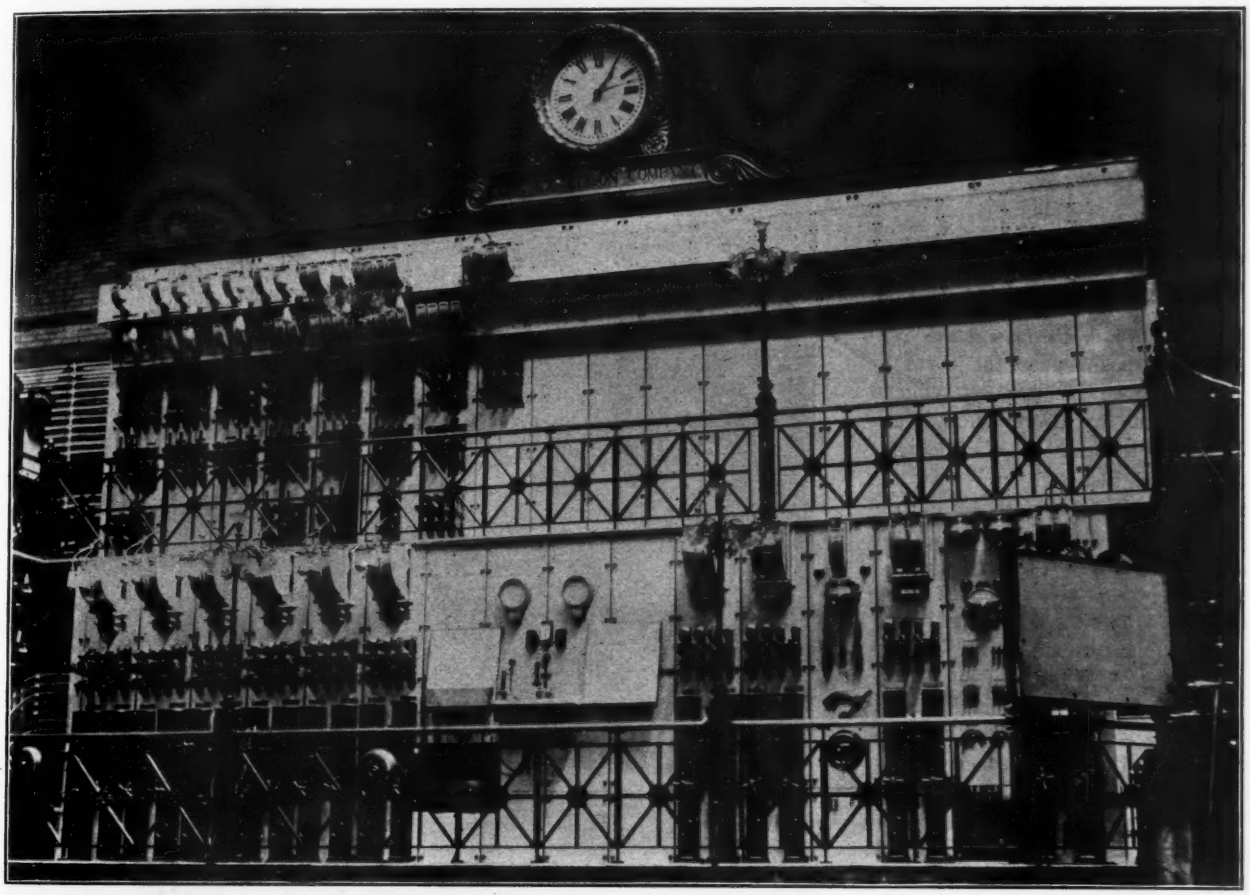


LOAD DIAGRAM, CHICAGO EDISON SUPPLY SERVICE.



LOAD DIAGRAM, TOTAL OF LOW-TENSION SERVICE.

lutions per minute. These double-current machines are wound to give 150 volts on the direct-current side and three-phase alternating current at the corresponding voltage on the other side. In addition to these units there are six 1,200-horse-power sets, generating direct current and employing Southwark engines, these being mounted in the same way as those already described. One of these sets, it is interesting to note, was that exhibited at the World's Fair, and then regarded as a monster among electrical generators.



THE MAIN SWITCHBOARD OF THE HARRISON STREET STATION, CHICAGO EDISON COMPANY.

At the end of the room is one double-current generator of 2,500 kilowatts capacity, normal rating, and 3,200 kilowatts, three-hour overload rating, mounted on the middle of the crank-shaft of an Allis vertical cross-compound engine of a maximum output of 5,000 horse-power. This gigantic machine gives 300 volts on the direct-current side and 6-phase, 25-cycle current on the alternating-current side when running at 75 revolutions per minute. It possesses a number of interesting features on account of its great magnitude. The collector rings for taking off the alternating current are 90 inches in diameter and each carries 48 brushes. The armature is 21 feet 8 inches in diameter and the commutator is 15 feet in diameter and has 960 bars. The machine has 40 poles, and in all 560 brushes bear on the commutator. A 75-ton flywheel is mounted on the armature shaft to steady the rotation of the machine. The engine has cylinders 38 and 84 inches in diameter by 60-inch stroke, and is rated at 3,500 horse-power, with a maximum output of 5,000 horse-power.

Alongside of this unit another of somewhat larger size is being erected, the new machine being a 3,500-kilowatt alternator generating directly three-phase current at 9,000 volts with a frequency of 25 cycles.

The main switchboard is remarkable for its large proportions and solid construction. It is excellently shown in the accompanying illustration. The outgoing direct-current trunk line to the large storage battery station aggregates 66,000,000 cir. mils. On the controlling panel for the new 2,500-kilowatt double-current generator is mounted an ampere-meter reading direct to 12,000 amperes. The outgoing high-tension feeders are handled by oil compartment switches made by the General Incandescent Arc Light Company. These switches are used in considerable number in the substations also, and are of the solenoid-operated type, the plungers of the switches working under oil in brick chambers.

In the aisle in the middle of the station are located banks of transformers which step up the current from the alternating side of the 200-kilowatt double-current machines for transmission to outlying substations. As a further source of alternating-current supply for this purpose there is installed a 250-kilowatt rotary converter which is operated reversed—that is, fed from the direct-current side and operated in parallel with the double-current machines. By the use of this remarkably flexible system of double-current generators, rotary converter and direct generation both of direct current and polyphase current, an economical load for the engines can be secured at any time. The Harrison street station is operating practically at the limit of its present generating capacity, the peak load being as much as 17,800 kilowatts, and when the engines and generators now being installed are completed, the station will have reached its ultimate capacity of 27,000 kilowatts.

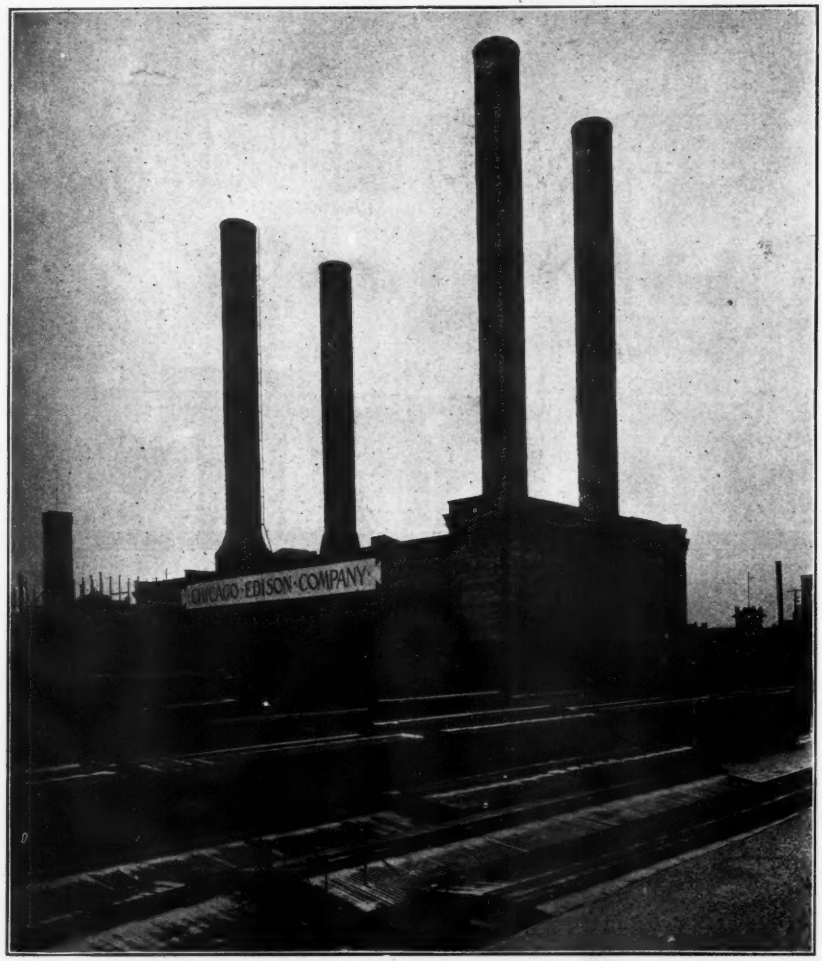
OTHER GENERATING STATIONS.

The direct-current service is limited to

Boiler Room of the Harrison Street Station.

the district shown on the map as the "central district," bounded on the north by North avenue, on the west by Ashland avenue, on the south by Thirty-ninth street, and on the east by Lake Michigan. Outside of this district, in three sections of the city, called for purposes of convenience the northern, western and southern districts, distribution is by means of alternating current at sixty cycles, operating upon a four-wire, three-phase system having a maximum of 2,400 volts between the neutral point and any one of the outside terminals at the generator. The choice of this method of distribution was determined by the consolidation with the system of a number of single-phase stations which have been operating in the outlying districts of Chicago, and it was decided to adopt a method of operation which would permit utilization of the existing circuits owned by these concerns, while at the same time giving the benefit of polyphase distribution wherever motors were encountered in these regions. As unbalancing is a less serious difficulty on a three-phase star-connected plant than elsewhere, the system was chosen and the voltage at generators made such that they would operate from 2,000 to 2,400 volts. This gave ample allowance for drop in supply lines and permitted the use of standard transformers having 2,080-volt primaries. In order to supply this region there are three principal stations, one in each of its three divisions, some of which present very interesting features.

The northern district station, known as the Lake View station, is connected with the Harrison street plant by means of a transmission line over which 9,000-volt, twenty-five-cycle, three-phase current is sent and received upon motor-generator sets which are practically frequency and voltage transformers. These machines receive on their motor side the 9,000-volt, three-phase current at twenty-five cycles and turn out on their dynamo side three-phase current at sixty cycles with a maximum of 4,150 volts between phases and 2,400 volts between the neutral or fourth wire and any outside terminal. It is the company's intention ultimately to shut down entirely the steam generating plant in this station and to operate it as a substation of the general character already described. At a point known as Edgewater, a suburb lying four miles north of the northern station, there was formerly a three-wire direct-current distribution. This has been changed over by the installation of large transformers having three-wire secondaries, these being fed by means of a 5,000-volt, sixty-cycle line from the northern district station. Great satisfaction has followed the adoption of this method of supply for this district.



The Harrison Street Station of the Chicago Edison Company.

In the western district a substation is situated on West Madison street, the latter being connected by a transmission line

COAL POCKETS IN THE HARRISON STREET STATION.

to the main station at Harrison street and containing motor-generator sets similar to those described above. The distribution from this station and substation is also on the four-wire three-phase basis.

The southern district has a fine generating station situated in Fifty-sixth street and supplying an area comprising about sixty-five square miles. This station supplants no less than six generating stations which were formerly operated by as many different companies. In the southern district also the four-wire three-phase distribution method is used, while the substation method of subordinate distribution is carried out in this district to a very great extent. At these substations there is no machinery other than the switchboard and transfer and balancing switches, potential regulators and other governing and measuring apparatus. For a more complete account of these substations and their methods of operation the reader is referred to a paper read before the American Institute of Electrical Engineers, November 22, 1901, by Mr. Louis A. Ferguson, the company's general superintendent. The various installations in the district outside of the central district are operated by the Commonwealth Electric Company.

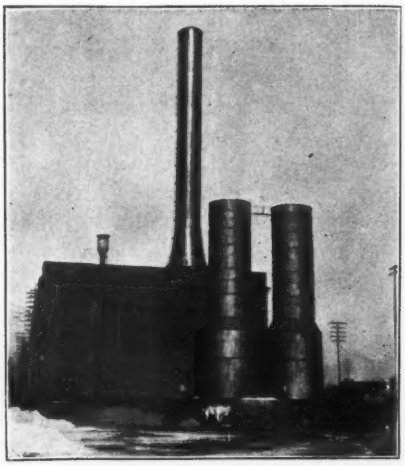
DIRECT-CURRENT SUPPLY SUBSTATIONS.

There are located in the central district, where the supply to customers' premises is by direct current, at present nine substations, one of which contains the largest storage battery installation in the world. The general type of the other substations may well be understood from a description of the Dearborn street substation, which is located in the very heart of the business district of Chicago, in the basement of an office building.

The apparatus at this substation consists of three 500-kilowatt rotaries of an eight-pole type, receiving six-phase current and feeding direct current into the outsides of the three-wire low-tension direct-current network. Here also are installed nine transformers receiving 9,000-volt current from the Harrison street generating station and transforming it in voltage, and at the same time in phase relation to six-phase, with the necessary regulators in the secondary circuit. The transformers are connected in delta on the primary side and each bank of three is controlled by a switchboard of unusually ingenious and simple construction. This board is of what may best be called a "compartment type" and is built throughout of slate and metal. The bus-bars con-

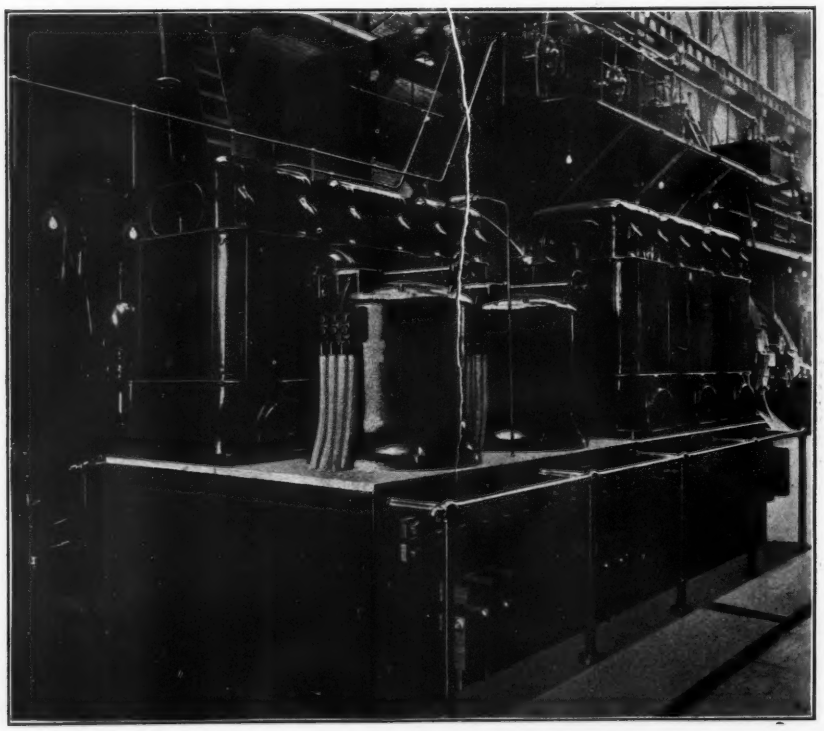
A 400-K. W. DOUBLE-CURRENT UNIT IN THE HARRISON STREET STATION.

sist of copper cables whose centres are seven inches apart, each being isolated from the others by slate separating barriers. The three poles of these switches are all in separate cast-iron boxes, one high-tension oil-break switch of the pattern used on the Harrison street switchboard being installed on each of the two incoming transmission lines. The switchboard for distributing the direct-current supply is of a very compact type, as is shown in one of the illustrations, the instruments being of the Weston edgewise type and switches of a laminated construction which are standard for the Chicago Edison Company. The shunts for the various meters consist simply of given lengths of the cables, no built-up shunts being used. On account of the considerable temperature coefficient of copper, the shunt circuits are led through coils closely wound around part of the cable, and so arranged that any heating of the latter also heats these coils which are in series with the measuring instruments, thus compensating for any irregularities that might arise from temperature changes.



THE FIFTY-SIXTH STREET STATION, CHICAGO

BOILERS IN THE FIFTY-SIXTH STREET STATION, CHICAGO.



TRANSFORMERS AND REGULATORS FOR OLD DOUBLE-CURRENT UNITS, HARRISON STREET STATION.

Copper fuses of the Ferguson type are used on this switchboard. All the apparatus in this substation is installed in a basement in which there is only nine feet head-room and the installation is one of the most compact in existence, considering its size. It is proposed to install in future three additional units, thus making the total capacity of the substation 3,000 kilowatts. Forced ventilation is used, the transformers being of the air-cooled type with forced fan draft.

Other substations, in localities where property can more conveniently be had, are located in buildings constructed specially for the purpose and consisting in general of two stories and a basement. In the latter, in some cases, it is proposed to install storage batteries. The main or ground floor is given over to the rotaries, transformers, regulating instruments and switchboard, while the upper floor forms sleeping quarters for the men in charge. These buildings have been designed very carefully to meet the object of their construction and are built of brick upon excellent architectural lines.

THE ADAMS STREET STATION.

The original generating plant of the Chicago Edison Company was situated in a large building in Adams street, opposite the post office and nearly at the centre of the business district of the city. The gen-

erating apparatus formerly operated in this station has been removed, and in it has been installed one of the largest storage battery plants in existence.

PART OF THE ADAMS STREET BATTERY STATION OF THE CHICAGO EDISON COMPANY.

Some difficult problems were encountered in providing from drainage, for supports for the great weight of batteries installed, and the ventilation of the battery room. Most elaborate provisions were made in all these directions, with the result that although the immense batteries are installed in the basement of the building the ventilation is so thorough that no gases are noticeable in any part of the building, the upper floors of which are used for the company's general offices and draughting rooms, etc. The floor of the battery room is built of vitrified tiles laid in a mixture of asphalt and coal tar; the abutments of the supporting iron columns are enclosed in the lead, the columns being further protected by wire lath, over which a layer of cement plaster is placed, this being covered with acid-proof paint. The walls and ceilings are also treated with the same plaster. The ventilation system consists of inlet and outlet ducts for blowing in fresh air and exhausting the vitiated air of the rooms. The first installation of battery consisted of 166 cells, of which sixty are end-cells, eighty-three cells being mounted on each side of the three-wire system. This installation has a capacity of 22,400 ampere-hours at eight-hour rate, and a maximum discharge capacity of 11,000 amperes for one and one-quarter hours. The end-cell switches are well shown in one of the illustrations, as is also a panel of the storage battery switchboard. Current is received over a feeder line having the enormous aggregate capacity of 66,000,000 circular mils from the Harrison street generating station to this important battery installation. Since the installation of the original set of cells, two similar installations have been put in, there being now three groups of batteries such as described above in the Adams street station. The cells are of the chloride type, each containing eighty-seven plates, fifteen and one-half by thirty-two inches. Each cell complete weighs 6,200 pounds, the weight of each of the three groups of batteries being a little in excess of 1,000,000 pounds. Each cell is mounted on ten double petticoat insulators resting on tiles laid on the acid-proof floor.

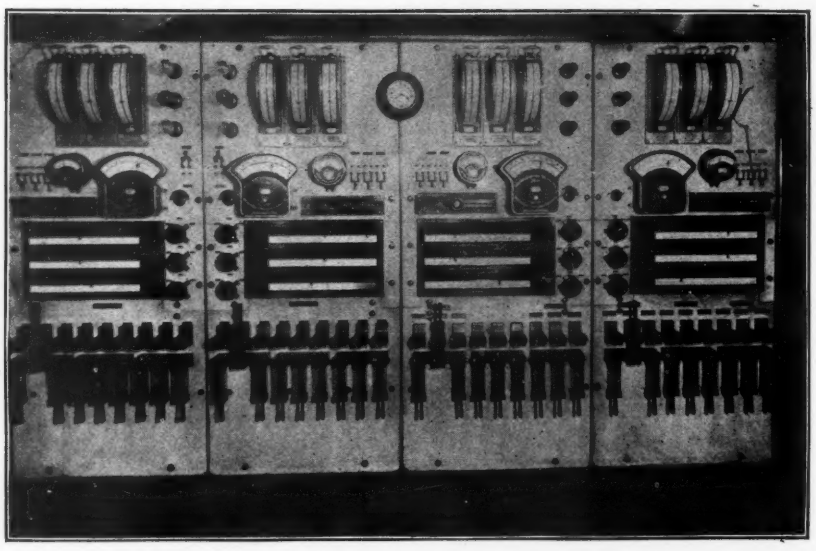
ONE OF THE CHAIN-STOKERS AT THE FIFTY-SIXTH STREET STATION.

The method of charge is very interesting, this being accomplished without boosters. The field regulation of the dynamos at Harrison street is governed by rheostats controlled by small motors

worked from the switchboard of the Adams street station.

THE DISTRIBUTING SYSTEM.

The conditions obtaining in the business centre of Chicago are peculiar to that



Regulating Panels for Two Batteries, Adams Street, Chicago.

city. As noted in an introductory paragraph of this paper, there is a very great condensation of demand of electricity supply in the small district south of the main branch of the Chicago River, and in this the power load is relatively very large. For the general system a statement dated September, 1901, shows that the total light and power load connected is equivalent to about 1,100,000 sixteen-candle-power lamps. Of this total 69.2 per cent was for lighting, 30.8 per cent was for power, and no less than 12.5 per cent of the total output of the companies was used for elevator service alone. The business district of Chicago, as every one knows, is a place of high buildings, and it is probable that in the small section of the city's business centre there is a larger total of elevator service per unit of area than almost anywhere else in the world.

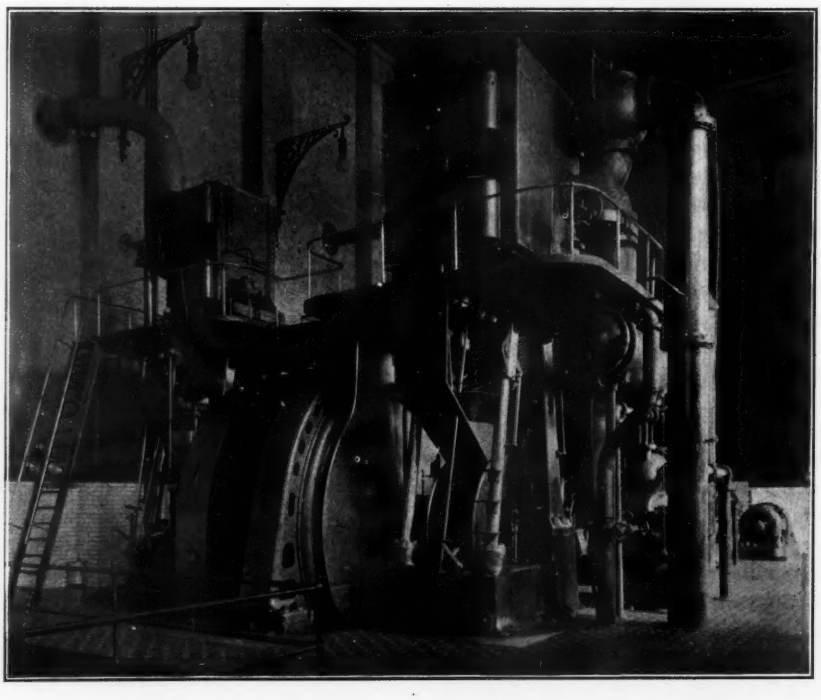
In the underground district, which covers several square miles, there are a number of types of conduit in use, laid between brick manholes. In addition to these conduits there is a large quantity of Edison tube used for mains. The latter is still being installed for this purpose in considerable quantities in Chicago on account of the great facility with which taps and branch connections from it may be made. None of it is used for feeders. Perhaps a better idea of the distributing system in general can be had from the accompanying map than from any description.

The system of charge adopted by the company over its entire distribution system is that known as the Wright maximum demand system. Each customer is supplied through a demand discount meter and is charged a base rate for light of one cent per sixteen-candle-power lamp-hour for the maximum amount used at any one time during the month, for one and one-half hours per day during the winter months, and one-half hour per day during the summer months. The balance of the wattmeter reading is charged for at the rate of one-half cent per sixteen-candle-power lamp-hour.

In charging for current supplied for power work a similar demand system is made use of, the rate being based on ten cents per kilowatt-hour for the maximum demand at any time during the month for a certain number of kilowatt-hours per month, the balance of the bill being charged on a graduated scale down to a minimum rate of four cents per kilowatt-hour.

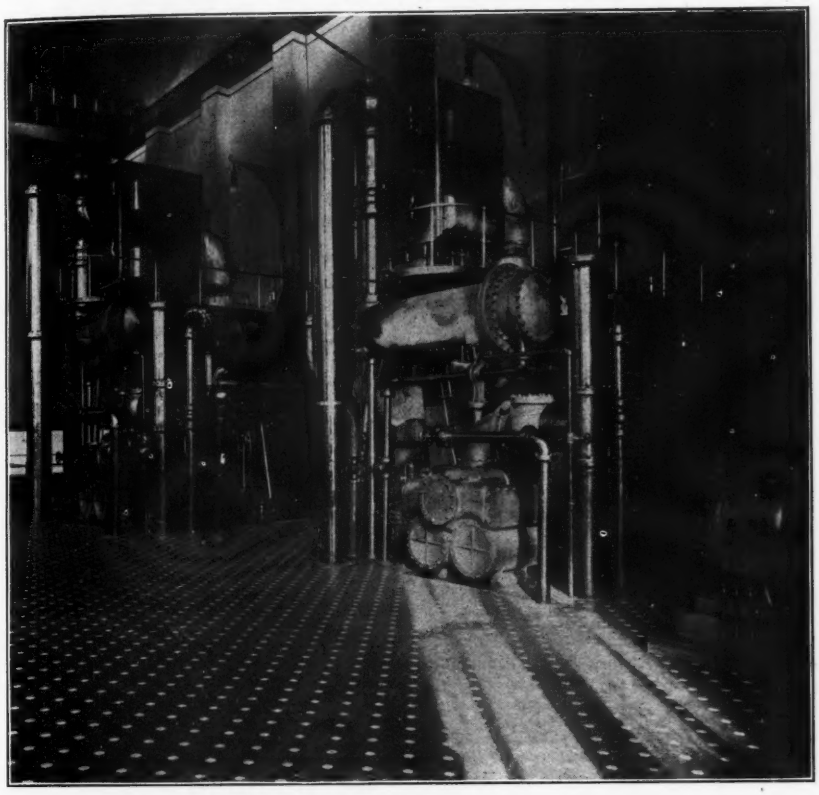
The large motor load also preserves a remarkable flatness of the daily load curve, as may be seen from the accompanying diagram showing average load curves for several years.

It is noted that no reference has been made above to arc lighting. The city of Chicago owns and operates a municipal street lighting plant, and for this reason the company's arc lighting is confined very largely to commercial lighting, using enclosed arc lamps on the 115-volt supply circuits in the city, although series arc generators are in operation in the outlying plants and substations for supplying street lighting to these sections. A very considerable business is done by the company, however, in time-limit interior arc lighting, this being sold to consumers at a fixed price per month. The circuits feeding such installations are arranged to pass through a switch enclosed in a case which may be opened by a key from the street. Patrolmen turn on and off the light at fixed hours for these consumers. Another somewhat notable extension of electric lighting in Chicago is in the use of electric signs, and to further encourage

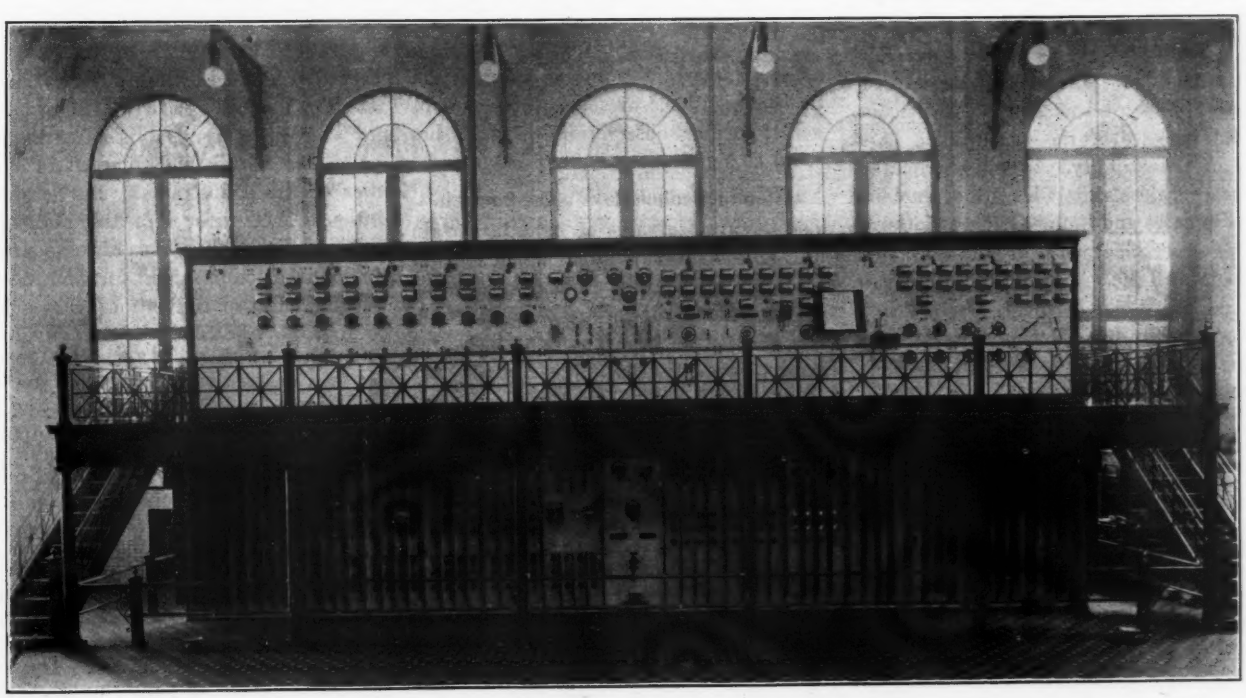


An Engine-Driven Unit in the Fifty-sixth Street Station, Chicago.

this particular source of demand the company has several standard types of electric signs which are leased to consumers at a fixed rental, the signs being also operated by means of the time-limit arrangement described above.



ENGINE-ROOM OF THE FIFTY-SIXTH STREET STATION, CHICAGO.



SWITCHBOARD AT THE FIFTY-SIXTH STREET STATION, CHICAGO.

CONCLUSIONS.

The Chicago Edison Company is a remarkably successful business corporation. Capitalized at $6,000,000, its stock is quoted at 160 on the local exchange. On account of the municipal lighting plant its business is principally confined to the supply of electric current to private consumers and in this regard it is without competition in Chicago, except in so far as isolated plants may be regarded as competitors. The isolated plants are, however, very largely disappearing, some of the largest consumers in Chicago preferring the supply from the street mains. One of these consumers has over 7,000 lamps connected in addition to forty elevators and motors.

The particular interests attaching to this admirable system are its flexible system of current generation and distribution and the fact that it makes use of practically every variety of electricity supply to meet the local demands of different sections of the vast territory embraced by its operations. Thus, in the down-town business section, light supply is by direct current; in the outlying and resident districts, light supply is by sixty-cycle alternating current, this being ordinarily single-phase, but with the capacity for polyphase supply wherever it is necessary to install motors. Generation is standardized on a polyphase basis at twenty-five cycles and 9,000 volts, and the generating stations so connected that anything resembling a total interruption of service is practically impossible. This source of trouble is still further guarded against in the heart of the city by the reserve capacity of the immense storage battery. On such occasions as may sometimes arise through the bursting of a boiler tube or other accident this reserve capacity has already proven its great importance and value.

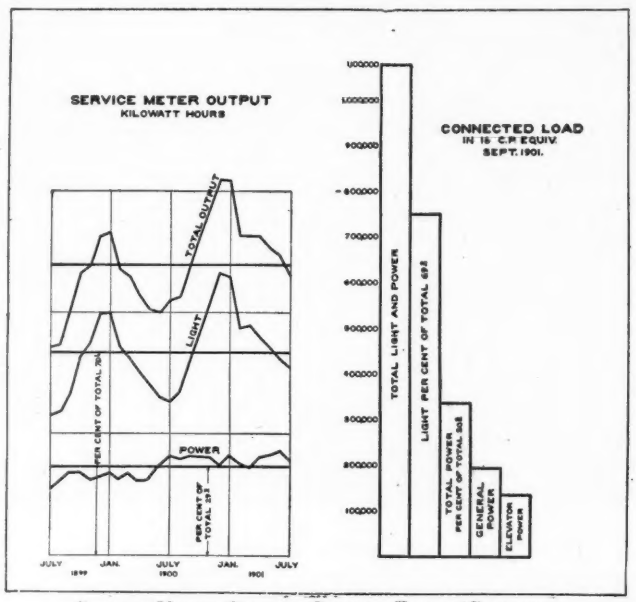
It would not be proper to conclude this hasty survey of one of the most compre-

hensive and interesting electrical installations in the world without some reference to Mr. Louis A. Ferguson, the general superintendent of the companies, under whose high technical skill and executive ability this system has been brought to its present state of satisfactory operation. The administrative side of the business has also been handled with remarkable competence and ability by Mr. Samuel Insull, president of the company, and his associates, Mr. F. S. Gorton, secretary and treasurer, Mr. W. M. Anthony, comptroller, and Mr. R. C. P. Holmes, purchasing agent.

Science Brevities

Electron Theory of Light — Herr W. Voigt has made the attempt to formulate an electron theory of the changes in the optical properties of ponderable bodies produced by mechanical and thermal deformation. An account of his work has been published in the *Comptes Rendus,* and digested in Fournier d'Albe's abstracts. The electron theory assumes the existence within ponderable bodies of corpuscles oscillating about approximately fixed positions. But both the quasi-elastic force which drives the particle back to its mean position and the resistance it experiences in its vibrations or revolutions hitherto lack electrodynamic explanation. The author shows, however, that the quasi-elastic forces decrease when a liquid undergoes compression, so that the stability of the oscillatory electrons is lessened. A rise of temperature under constant pressure leads, on the other hand, to an increase of the quasi-elastic force and of the stability. In solids the exact reverse is the case. The author explains how in gases and liquids compression produces a displacement of the spectrum lines toward the red, owing to the decrease of the quasi-elastic forces, and investigates in detail the effect produced by adding the same solute to different solvents.

Magnetization by Lightning — Some further results of the exposure of basalt rods to induction by lightning are communicated by F. Pockels in an article in the *Physikalische Zeitschrift,* which has been abstracted in the London *Electrician.* The rods were mounted near the lightning conductor of the Monte Cimone Observatory. One rod was mounted in its place in September, 1900, and could not be removed until June 3, of this year, owing to the configuration of the snow. The magnetization indicated a maximum current intensity of 5,600 amperes in the lightning flash. But as the date of the flash is unknown, and much of the magnetization may have been lost, this figure only represents a lower limit, two further rods, recently influenced by lightning discharges of known date, showing magnetizations indicating a current strength of 5,000 amperes and 3,600 amperes, respectively. Since they were attached to the two branches of the earthing conductor, respectively, it may be assumed that the total current strength of the flash was 8,600 amperes, or a little more. Some other rods exposed to a flash on August 13 showed no trace of magnetization, and the author supposes that there are oscillatory lightning discharges, and that this was one of them. It would be well if personal observations of the flashes could be simultaneously recorded.



SERVICE METER OUTPUT, CHICAGO EDISON COMPANY.

Action of Radium Rays upon Bacteria — The therapeutic value of light in certain diseases suggests a similar action of Becquerel rays. Herren E. Aschkinass and W. Caspari have discovered such an action. An abstract of their work, which was originally published in the *Annalen der Physik,* has been published in the London *Electrician.* They employed the method devised by Herr Buchner for demonstrating the bactericidal action of light. A layer of agar-agar containing germs of *micrococcus prodigiosus* was poured into a flat glass dish and allowed to set. The dish had black letters painted or stuck on its cover, and light was admitted from above. After a couple of days the portion of the nutritive medium below the letters was colored deep red by colonies of the *micrococcus,* while the exposed portions were quite clear. On exposing a similar culture to a radium preparation contained in an aluminum capsule no effect was produced. But an exposure to the rays from the bare preparation killed the germs very effectively in about three hours. The authors made sure that the effect was neither due to phosphorescence nor to ionized air, nor to bromine vapor. This shows that the effective rays are those which are more easily absorbed, and the physical distinction between the two classes of radium rays is thus emphasized by a marked physiological difference.

Pressure Exercised by Light — Herr P. Lebedew has succeeded in demonstrating, both qualitatively and quantitatively, the pressure exercised by light, which is postulated by Maxwell's theory. The results of his work have been published in the *Annalen der Physik* and digested in Fournier d'Albe's abstracts. The obstacles hitherto met with were the radiometer action, which is thousands of times stronger than the action sought for, and the disturbing effect of convection. The author eliminated the latter by reversing the illumination repeatedly, and the former by high exhaustion, a large bulb and the exclusion of rays capable of heating the walls of the bulb. To facilitate a rapid equalization of heat in the radiometer vanes, he made them of very thin aluminum foil suspended torsionally by a glass thread arranged as in the Cardani suspension. The light used was that of an arc lamp, and its incident energy was determined calorimetrically. The surfaces of the radiometer vanes, which were either plain or blackened, were tested with regard to their reflecting powers. The absolute error of the aggregate measurements was twenty per cent. The results agree with the theoretical values of Maxwell and Bartoli within ten per cent. The pressure is directly proportional to the energy of the incident light, and independent of its color.

Distortionless Telephone Circuits.

AT the summer meeting of the Institute of Electrical Engineers, in Philadelphia, in the year 1900, Dr. Michael I. Pupin, of New York, presented a paper on wave transmission through complex electrical circuits. In this paper was modestly set forth the details of one of the most important inventions that has been made in the history of the telephonic arts, an invention that is remarkable in several ways, but principally on account of the use which was made of mathematical analysis in arriving at the results obtained.

MICHAEL I. PUPIN.

There are few fundamental problems in physics which have not already been attacked and solved. One of these was the discovery of the laws governing the vibration of a heavy string or cord in a resisting medium—a problem in most respects exactly analogous to that of the transmission of electrical waves over a conductor having inductance, capacity and resistance. In the monumental analytical works of Mr. Oliver Heaviside some reference had been made to this problem, particularly as it affected electrical circuits and transmission over them, but the eminent English mathematician had stopped short of a reduction to practice of his far-sighted analyses and had in terms only stated the conditions of the problem instead of offering a solution for it.

Attracted by a desire to discover, if it were possible, some means of bettering electrical wave transmission over conducting circuits, Dr. Pupin went to work analytically to determine the laws governing the effect of the three fundamental electrical constants of such circuits upon waves transmitted over them, and particularly to discover some method of producing in practice the effect which it was theoretically known would be accomplished by distributed inductance. To make more clear the conditions of this work, the effect of these various qualities upon an electrical wave may be briefly considered.

An electrical wave traversing a conductor suffers attenuation or a loss of energy, due primarily to the overcoming of resistance, much in the same way that energy would be lost were the electrical wave a material object traversing a resisting medium. On account of the qualities known as inductance and capacity, both of these terms representing actions taking place outside of the conductor, by which a certain proportion of the kinetic energy of the electric wave is stored up in the surrounding medium in the form of potential energy—electrostatic in the one case and electromagnetic in the other—the wave also suffers, if it be a complex wave, a certain displacement in phase due to the restoration of energy to the circuit from the surrounding medium, and causing a separation of the components of electromotive force and current in the wave itself.

In the case of a complex wave, which practically covers all classes of electrical waves used in telephony or telegraphy, a further and very serious effect, known as distortion, is observed. this being due to the fact that the various harmonic elements which are the components of such a wave suffer different degrees of attenuation and displacement on account of the electrical constants of the wire.

At the same time it was known that if inductance could be distributed through a circuit in the same way that capacity naturally distributes itself, the effect of the two would be to counterbalance one another, and the only change suffered by a wave passing through such a circuit would be the natural attenuation or dying out due to the resistance proper of the circuit. This, it is seen, would not change the shape or character of the wave.

The problem which presented itself was how to secure the effect of distributed inductance. Of course it is easy enough to add inductance in the shape of coils to a circuit, but to discover the proper size for these coils, the proper distance apart to place them, and the proportions which they should bear in other respects to the circuit, was a task of no small difficulty. The problem was identical with that of adding weight to a vibrating string. If a string of small weight is vibrating in a resisting medium naturally its vibrations will be dampened and will waste away by the resisting action of the medium. If, now, the string may be made heavier without losing its qualities of elasticity, etc., it is perfectly evident that vibrations impressed upon it will travel further and retain their shape better. How to add weight to the string was the point. It could be added at certain intervals, and if these intervals were sufficiently close, if the string, for example, were strung with heavy beads, practically the same effect as would be obtained from a heavier string would be secured. Analytical work, marking the first stage of the problem, was therefore directed at finding the proper weight and distance apart of the beads necessary to secure an effect comparable with that of a uniformly heavy string. Returning now to the electrical problem, the very brilliant mathematical exploitation of the subject by Dr. Pupin showed that a formula of remarkable simplicity could be devised, giving the necessary data for the construction of inductance coils to be placed at predetermined intervals in any given circuit to produce results so nearly comparable with those that might be expected from distributed inductance as to allow the passage of electrical waves of a complex character without serious distortion. The next step, of course, was experiment.

Upon the application of these inductances to a cable having the constants of a telephone cable, it was immediately discovered that conversation, which in such a cable became weak at twenty miles, and practically impossible at fifty miles, was easily possible with the coils in place over 250 miles. It was at once recognized that here was an invention of the utmost practicality and value. It is pleasant to be able to record that this view was shared by the American Telephone and Telegraph Company, which purchased the patent right of the invention from Dr. Pupin at a large price.

The effect of the commerical introduction of this improvement in telephone circuits may now safely be foreseen from results that have already accumulated in practice. In city cables the inductance will be added in the shape of coils of small dimensions placed appropriately in manholes of the existing cable systems. For cross-country or long-distance lines, the coils will be mounted in appropriate waterproof cases and connected with the line at intervals of a mile or two on the poles. The immediate results that may be expected is a very considerable extension of the distance at which telephone conversation is practicable, and an immense improvement in conversation over long underground city lines, such as may be found in New York and Chicago, for example. Whether or not it will be possible to introduce in future practice a cable having a larger number of circuits of smaller wire can not yet definitely be said, but it is thought also that this improvement may be possible, thus greatly enlarging the capacity of present conduit systems for telephone cables.

At the time of the announcement of Dr. Pupin's invention it was extravagantly asserted in newspapers that the problem of telephony across the Atlantic had been solved. To a certain degree this is true, as it is beyond doubt that a cable could be constructed suitable for telephone conversation at this distance upon the new system. But the most practical advantage which will accrue to the art of cable-making from the extension of this method is that it will enable high-speed cables for telegraphic service to be constructed and laid.

It is hoped that the near future will see the installation of a long submarine cable employing this method, over which may be used machine telegraph methods of great rapidity.

Present Tendencies in Electric Traction.

By Louis Bell.

TO REVIEW the history of electric traction up to the present is rather a thankless task. History needs perspective, and this is almost as difficult to secure in current science as in current politics. Yet in order to get any definite idea of the present situation one must run back over what has been done in order correctly to appreciate the bearing of what is doing to-day.

The first task of the electric motor in traction was a formidable one, attacked with no little trepidation and, at first, with a very modest degree of success. It was, in brief, the displacement of animal traction on the then existing tramways. Fifteen or twenty years ago street railways were on a very humble scale. We all remember their equipment—the short and low-roofed cars trundling over the old strap rail laid on stringers, the dust of summer and the reeking straw of winter, the spavined horses or the bob-tailed mules in front. They had a happy-go-lucky schedule then; the cars turned off the track to pass each other if a siding did not chance to be convenient, and, in some northern cities, when winter came the wheels came off and runners went on until the snow melted.

Everything was lightly built then, including the motors, and when electric power was introduced nearly everything went to pieces—also including the motors. But the early work showed very plainly three things: That considerably more power could be applied to a car by motors than by any reasonable number of animals, that this power was under more effective control, and that, on the whole, the power was cheaper. Hence the cars could make better speed, could hold to schedule and work through a blockade more readily, and could get more business at the same cost for motive power. The immediate effect was to push the electric railway to the front, gradually driving the horse railway from supremacy into disrepute, from disrepute into disuse. It will end by passing from disuse into oblivion. In all New England the writer chances to know personally but one operating horse railroad—a tiny affair at Fryeburg, Me., with cars too small even to convert into "owl" lunch carts—the frequent fate of disused horse-cars.

But the electric road has done much more than this, as events have turned out. It has completely and radically changed our ideal of tramway traffic. The immediate need of better track and solider cars, made evident by purely mechanical considerations when increased speed was tried, very quickly brought larger and more commodious rolling stock fitted to cope with heavier traffic, and a suitable road-bed upon which to operate it. What the development of the horse-car would have been without the electric stimulus one can only conjecture. From appearances it would seem as though considerable improvements might have been expected, but they would have been very limited, for long and comfortable cars require more power, even at moderate speed, than two horses can supply, and a four-horse car is far too unwieldy for general use in city streets. And by and by, with speed, the bogie truck came into tramway service, bringing increased safety when running fast, and large easy-riding cars with which to gain increased traffic.

The adoption of the bogie truck was the first considerable move in the direction which has been characteristic of electric railway development in this country. This is the evolution from tramways of an anomaly in traction—an immensely useful and important system which is neither tramway nor railroad, but something between the two, poised in rather unstable equilibrium and librating between two radically different positions. It is the existence of this stage of evolution which gives the present situation much of its interest and tinges it with a parti-colored uncertainty as to the future.

Once given higher speeds than had been wonted, the electric railway quickly began to try the possibilities of suburban traffic. What it has done in opening new regions to homes and in reducing the enormous waste of time in reaching the urban business centre would fill a book, and a mighty interesting one. From the extension of purely tramway service has come the ordinary suburban electric road, out of the latter has been evolved the interurban road, with all its possibilities and opportunities. This evolution has been so gradual that one has to think it over before he realizes its full import. The running speed of electric cars has gradually risen, and each rise has brought a new zone of suburban country within reach. A little further increase in speed and another city comes within the operating radius, then perhaps another and another, until an interurban system is built up.

But there is still another sort of interurban road of more recent growth, which implies a later stage of evolution. This is the interconnecting road joining two or more cities which have no intersecting suburban zones. Here the interurban electric road is built where twenty years ago a steam road might have been built to parallel existing means of communication. There is, however, this radical difference, that the electric road, running often through streets and public roads, although sometimes over its own right of way, touches public convenience far more closely than a steam road on an isolated right of way, with infrequent stations, ever can, and gets the lion's share of the traffic. From such a system to a third-rail line operating over its own way and with definite schedule and stations is but a step and our evolution is complete, passing by almost insensible gradations from a humble tramway, permitted to run through the streets as a matter of convenience to the public and picking up its traffic within narrow urban limits, to an electric railroad running cars at express speed between city and city, and, so far as passenger traffic is concerned, fully able to compete with any existing trunk line.

This development has brought with it a vast change in the needs, duties and responsibilities of the electric road and have brought it into a state wherein its future relations are somewhat uncertain. The nature of these uncertainties and the conditions that give rise to them form an interesting study, in which plain speaking is just now pertinent.

There has been, during the past few years, a very strong tendency toward the consolidation of electric roads, producing in urban traction homogeneous systems of more or less rapid transit, and outside of them through lines and extensive networks differing in function from ordinary railroads chiefly in that they carry only passengers and seldom run through cars. What is to be the relation between such systems and ordinary railroad lines, and how do the fast interurban roads stand related to both?

Now putting aside our natural prejudice in favor of electric lines it must be admitted that an interurban road running heavy cars at speeds of twenty miles an hour and upward, with stations, with or without buildings, at fixed points is in all essential respects an ordinary railroad. That it uses electric motors instead of locomotives is of interest to the public

chiefly in that the motors make no smoke. There is no logical reason why such a road should be relieved of any of the responsibilities of a steam operated road, even when it runs upon its own private right of way, and especially if it does not. When it does own its right of way and takes to the third rail it even more obviously passes the line that separates it definitely from tramways of every sort. In other words, while the discussion of steam *vs.* electricity has been going vigorously forward, an answer to the questions involved has been furnished in the building of a considerable class of electric roads that differ from ordinary railways mainly in their less rigorous enforcement of the ticket system in the absence of suitable waiting rooms at stations, and in too frequent neglect of the ordinary precautions for safety that years of experience have shown to be necessary on railroads maintaining a far less frequent train service.

There has been a current feeling that with electricity as a motive power "everything goes," and the writer has in mind one long electric road running heavy and fast cars over rickety trestles that have required wholesale rebuilding since it went into the hands of a receiver to ensure the reasonable safety that the original builders neglected. The last year or two has seen a series of fatal catastrophes on fast electric lines that could have been averted, in all human probability, had the roads taken half the precautions that the character of their traffic demanded. When electric cars run at high speed through fog and around sharp curves on a single track it is or should be an utterly futile excuse to complain that the brakes slipped when a crash occurs. The wiser heads in the business are beginning to introduce a proper block system and telephonic or telegraphic train despatching, and these precautions, with suitable care at grade crossings, are properly as much a part of fast interurban electric service as of that accomplished by any other motive power. It is doubtless somewhat inconvenient and expensive to take such precautions, but it were well to heed the handwriting on the wall, and to do cheerfully and with good will what otherwise will very shortly be enforced by the iron hand. This advice may be unpalatable, but the event will prove that it is sound engineering and good morals.

Near urban termini, too, the fast interurban roads are finding themselves in a rather difficult situation. It is highly desirable for both the road and the public that it serves for it to fairly enter the city and set down its passengers near the business district without change of cars. Changing cars is sometimes a necessary evil, but, uniformly, an evil to be averted if possible. With modern car equipments it is, fortunately, possible to bring the speed down within proper limits for urban running, but there is a tendency so to increase the weight of the cars and the tread of the wheels as to make these extraneous cars uncomfortable visitors on track, and especially tram rails intended for urban traffic. Hence, each road must settle for itself the question of how far it is desirable to enlarge its equipment for high interurban speeds, bearing in mind its urban limitations. But evidently there is a limit, and a not very distant one, that can not well be passed without incurring trouble at the termini. The limitation is not upon the growth of interurban systems, which will, as they should, flourish and multiply, but upon their trying to walk two divergent ways at once. Just now the interurban line is usually neither tramway nor railway, and this status is one of unstable equilibrium.

The natural result of such a situation is that there should be produced an unwritten distinction between roads that confine themselves to tramway conditions and those that diverge toward ordinary railroad practice. In other words, the interurban roads have come, in the course of their development, to the parting of the ways. They must choose implicitly, if not openly and under compulsion, whether they will conform to tramway limitations as to speed and equipment and enjoy the immunities of tramways, or take openly the position and duties of passenger railways operated by electric motors. Either position is a highly important and remunerative one and meets a real public need, but the gulf between them is too wide readily to be spanned.

Roads which operate in and through small towns need not for the present be troubled by the situation, since their traffic conditions are vastly simpler than in the larger systems, but the latter are face to face with a serious problem.

That many electric roads now building and projected have placed themselves squarely on the railroad side of the fence admits of little doubt, and it is equally probable that in the near future we shall have many more such roads, some of them working at very high speeds. The high-speed road has been several times projected in this country, and once, in the case of the Chicago-St. Louis line, came quite near to realization. Even at that time there was no doubt that the engineering part of the problem could have been successfully carried out, but it has been left to the German experimenters at Zossen to build and operate the apparatus. The measure of success already attained is such as clearly to indicate that when any one wants in earnest a schedule speed of a hundred miles an hour, it can be provided. But American enterprise seems to have staggered at the financial end of such a proposition and there is every reason to believe that the honor of achievement is to fall to the Germans. There is small reason to think that the American lines will slowly work up to these high speeds before the Zossen experiments have borne commercial fruit. It is unpleasant, but, after all, it does make a material difference whether the financiers of a country think of new enterprises on a six per cent or a three per cent basis.

The advanced methods used by the Zossen workers have found little favor on this side of the water. It is obviously a serious matter to break into the steady and productive train of standard railway equipments with a line of apparatus that might lead to wholesale changes, and the experimentation, besides, is on a rather formidable scale. The writer, however, is strongly of the opinion that for high-speed work on a large scale the use of polyphase distribution directly to the motors presents so great advantages as to make any other method yet suggested of more than dubious utility. There can hardly be an effective distribution of the amount of energy required for this class of work without transmission at higher voltages than can be utilized directly in continuous-current motors, and the system of substations with rotaries feeding massive working conductors will be found very poor economy on long lines. The chief objection to traction by polyphase motors is the trouble of securing efficient acceleration, and on long and high-speed roads with comparatively infrequent stops, this difficulty cuts little figure. The other objection most frequently raised is the necessity of working in connection with continuous-current traction at the terminals.

If one were at liberty to suppose that high-speed and long-distance traction is to come as a part of the gradual development of the electric tramway, such an objection would have weight. But it has already been pointed out that there is going on an inevitable differentiation between urban tramways and interurban electric roads. The rolling stock of the latter is be-

coming rapidly unsuitable for the former and, desirable as interchange of rolling stock is, such an interchange can not be freely carried on unless with severe restrictions. The long and short of it is that considerations of public safety do not permit a long continuance of the present programme of doing railroad business under tramway conditions. Up to a certain point all goes well, but the equipment of the longer lines can not be brought to cope with express train habits and remain suitable for running through city streets and other public ways.

Hence there must come about a clear distinction based on the kind of traffic attempted, and we shall have, on the one hand, urban tramways and their longer or shorter suburban connections; and on the other electrically driven railroads having termini like other railroads and doing a splendid work in quickening transit over long radii. Whenever a road, by its initiation or by evolution, reaches this stage, as many of them will in the next few years, its equipment has no more relation to the tramway equipment than that of the Pennsylvania Railroad has, and its nature can be determined on the merits of the question alone. When affairs reach this condition, adherence to our present "standard" continuous-current methods will be needless and perhaps futile. The very fact that these methods have been exclusively used in the evolutionary process will stand in the way of the larger developments of extreme high speeds. That final impulse must naturally come, as it is, in fact, coming, from outside the present pale of electric railway extension.

The hundred-mile-an-hour train has been long predicted, but its coming does not depend at the present time upon any engineering consideration. It does depend on commercial daring, involving the construction of a line long enough to bring out the full advantage of high speed. A line between Jersey City and Philadelphia, for instance, would be far too short to justify its existence as a high-speed road. Extended to Washington or Chicago it would revolutionize travel. Such a line must logically be between large centres distant enough to make saving of time an object.

If the problem of efficient speed control in polyphase motors is solved, as Ganz & Company strenuously claimed in the recent London litigation, it means revolution in the working of electrically operated railroads at all speeds. Such control once granted, continuous-current motors must have an uphill and losing fight for existence in that particular field. It is a pity that the London controversy took a form in which the real fundamental question dropped out of sight. When Preece and Blathy and Kapp unite in saying that a particular thing has been done, it may be a wise and conservative policy to reject the thing, but no amount of detailing unsuccessful experiments and raising objections to the plan proposed will put out of sight the positive evidence presented as to the facts. What the London investigation proved was that Mr. Yerkes and his allies had a stronger "pull" than Ganz & Company, which is vastly to the credit of American enterprise, but leaves unsettled the main technical question at issue. However, if Ganz & Company have the thing alleged, it can not long be kept in the dark, and its commercial exploitation will be only a question of time.

The coming year will probably see some most important work on some of the larger problems of electric railroading, although realization may come slowly. The work of the greatest practical and immediate interest is the wholesale introduction of electric traction on the heavier urban lines. In this work, which is extraordinarily severe, multiple unit control has done wonders, and save for exterior connections the ordinary standard methods of the present answer admirably. This urban rapid transit work, however, is of a class which should, to obtain the greatest benefits, be directly connected with the long and fast suburban lines so that through cars could be run. This condition demands community of motive-power systems, and something of ideal properties in each portion may have to be sacrificed to obtain the greatest utility from the connected whole.

Large interurban work is far more closely related to such elevated and depressed rapid transit lines than to tramways proper, and it may turn out that polyphase traction, however desirable in the former, may be blocked by the requirements of interconnection with urban lines.

To sum up the present status of affairs the two branches of urban traction, surface and other, are both in the way of growing along sound and fairly steady lines. The suburban and interurban lines are rapidly opening an operative gap between themselves and the urban systems. The proper suburban lines, not using very heavy equipment and moving at moderate speeds, must naturally ally themselves with the tramways proper and will form an increasingly valuable and homogeneous system. The heavy suburban and interurban lines at high speeds are through natural causes separating themselves from the tramways and approximating railroad conditions. As related to urban rapid transit they must affiliate, if at all, with the modern urban rapid transit systems, but are not likely to pass into high-speed and long-distance lines by a simple evolution. The hundred-mile-an-hour train is a matter which stands by itself and can not be regarded as an extension of present practice. It probably will require special methods and must prove valuable, if anywhere, in traffic between large and rather distant centres. The results so far obtained indicate that such work will be done by polyphase motors, which may force their way into the larger urban work, but give small promise for tramways proper. The whole course of growth in electric traction has been typical of organized growth generally—a steady process of evolution with concurrent differentiation, guided as usual by natural selection and the survival of the fittest.

The Charleston Exposition.

The South Carolina Interstate and West India Exposition it is expected will be at its best about the middle of January. The largest attendance will probably be during the months of February, March, April and May. Many of the buildings are said to equal in amount of floor space those at the Pan-American and are larger than the buildings at Omaha, Atlanta and Nashville. The management believes that the exposition will be a financial success, and in addition to having attendance within a radius of 300 miles, believes that the usual Florida travel will bring a great number for a week's visit at Charleston.

Government Purchase of Telegraphs.

Every telegraph company that was in existence in 1866, and every telegraph company that has been organized since that time has filed with the Postmaster-General of the United States its written acceptance under seal of the terms of the Act of Congress of July 24, 1866, agreeing thereby, in consideration of the right of way over post roads and through government land and under or across navigable waters, to transmit government messages at rates to be fixed annually by the Postmaster-General, and to sell its lines to the United States at a price to be fixed by arbitrators, one to be appointed by the Postmaster-General, one by the company, and the third by these two.

So all that is now, or has been required at any time during the past thirty-five years to secure government ownership of telegraphs, is for Congress to exercise its option under the law of 1866.

Still, it is not believed that the United States will ever undertake to run the telegraph business of the country.

Some Unconsidered Aspects of Wireless Telegraphy.

By Charles T. Child.

THE engineering world has been so much astonished at the remarkable achievement of transatlantic wireless telegraphy, lately accomplished by Mr. Marconi, that it has hardly yet had time to consider the matter of long-distance wireless telegraphy with reference to its various somewhat extraordinary aspects.

WILLIAM MARCONI.

It seems reasonably safe to assume that we are still without a syntonic system. If this be the case and a sending station is erected in Cornwall capable of affecting a receiver somewhat more than two thousand miles away, it would affect similar receivers practically all over the continent of Europe, while it would doubtless render wireless telegraphy of any sort in England, the northern half of France and neighboring regions impossible. The same remarks apply to the stations which may be erected in the maritime provinces of Canada or in eastern Massachusetts. For this reason it would seem that wireless telegraphy, even more than the art of telephony ever was, is a natural monopoly of the first class.

By "natural monopoly" is meant that to make such a thing operative it practically must be under such single control that interference will be eliminated. In order to ensure such control it is certain that international action of some sort would be requisite, and since the action of any party to such an arrangement could entirely destroy its usefulness, the value of wireless telegraphy as an adjunct in war, at least for long-distance operations, apparently disappears.

As to the sending of commercial messages by this means, it is doubtful if any present opinion is of value. Further results must be awaited and more must be learned about the capacity and capability of the system before any judgment of its merits can be passed. But from the nature of things it appears to be wise to restrain our enthusiasm somewhat and wait for actual results. We think it was Professor Ayrton who made the apt simile of the loud electromagnetic voice calling in the wilderness and the sensitive electrical ear hearing it in the distance. This is an almost exact analogy, and if one imagines a voice of transoceanic capacity roaring in England, it is easy to see how the electrical ears of Europe would be more or less deafened.

Another consideration that follows from the Cornwall-Newfoundland experiment is that it is likely that any signaling done anywhere in the world by such sending apparatus would affect sufficiently sensitive receivers anywhere else. The old hypothesis that wireless telegraphy signals were due to Hertzian waves must evidently be given up in view of these results, unless it is assumed that the earth is transparent to such waves—a seemingly impossible assumption. Apparently what takes place when a wireless signal is sent is a disturbance of the electrostatic condition of the earth.

If we may assume two charged objects whose relative sizes and capacities are very dissimilar, and imagine an electrical oscillation set up such that a current flows from the larger into the smaller and back again with rapid alternations, then it is evident that if another body is electrically connected at some other point to the surface of the larger object, capacity currents of the same periodicity will flow in the connecting circuit. If we make some such assumption as this it is evident enough that we may explain the passage of wireless signals apparently through a dome of sea-water about 350 miles high, as in the case of the Cornwall-Newfoundland experiment.

Making this assumption, and considering duly the relative sizes and electrostatic capacities of the planet and any objects that may be separated from it a certain small number of feet, and connected with it by conductors containing either apparatus for producing or recording electrical oscillations, it is seen that certain dreams lately indulged in concerning the possibilities of wireless power transmission have a possible basis; yet the very conditions of the assumption impose certain absolute limitations upon the possibilities either of signaling or of the transmission of power by such means. These conditions are determined by the possible relative capacities of objects which may be insulated from the earth and the earth itself.

If the earth were a smooth sphere surrounded by an atmosphere of invariable proportions and density, then it is not difficult to prove that if two equal and similar capacities were connected with it by equal and similar conducting circuits that an electrical disturbance made in one circuit might be duplicated in the other, with perhaps certain differences of phase. If three similar capacities were connected, then a disturbance set up in the conducting circuit of one would be divided between the other two in proportions which still are within the limits of calculation. But if a practically infinite number of such capacities are connected in a practically infinite diversity of ways with an earth surrounded by a heterogeneous atmosphere and presenting a surface capable of radiation in many places, then the conditions of the problem become so complex that all that can be said in the present state of knowledge is that the resultant effect anywhere would be incalculable.

Of course all the foregoing is based upon the somewhat violent assumption that the effects noted by Mr. Marconi are due to oscillations set up between two objects of dissimilar capacity by well-known means. This hypothesis may or may not be true, but in any event it is worth consideration and is interesting. If it is true, as it seems to be, then the necessity for a syntonic system is even more evident than it was before and the question of the actual availability and utility of wireless telegraphic methods turns upon the number and diversity of syntonic systems that can be simultaneously installed. In other words, it all turns upon the accuracy of tuning which may be possible. Conditions are somewhat as if two pianofortes were set up near one another and, with pedals down, a note sounded upon one. If they were perfectly in tune with one another the corresponding note on the other would also sound itself, together with all of its related octaves, fifths, fourths and other near-by harmonics. If the pianos contained an infinite number of strings only certain groups under these conditions in the second instrument would respond. If a system of syntonic transmission should be built upon such an arrangement as this it is evident that the sending notes of different stations could not be octaves of one another, or fifths of one another, or bear any other simple harmonic relation to one another. The very practical question is, how many different tonalities of sending stations could operate simultaneously with satisfaction and certainty?

These are, in brief, some of the first considerations which arise in reviewing the superb work which has been done by Mr. Marconi and his associates, and in considering the results obtained by them with relation to their practical utilization for actual long-distance signaling purposes. It is fortunate that no man can read the future. It is not intended here to cast any aspersion upon this splendid work or to belittle it in any way. What wireless telegraphy actually will do in the future only the future can determine. If it does no more than it already has accomplished, even then it will stand upon the historical records of electricity as one of the most interesting and astonishing achievements which mark its pages.

News from Great Britain.

(By Our Special Correspondent.)

THE arbitrator's award in connection with the electrification of the "underground" in London has been given rather sooner than was generally anticipated, and contrary to my general impression, already expressed, decides at once in favor of continuous-current working, a result which both companies immediately declared their intention of putting into effect forthwith. The signed report of the Hon. Alfred Lyttelton, K. C., M. P., the arbitrator in question, is a singularly non-technical document, and in it he is careful to state that his final pronouncement is by reason of the great element of experimentation introduced into the proposals of Messrs. Ganz, and that from a public point of view the "Circle" is not the line upon which to conduct a gigantic experiment of the kind. This is the first time in the history of the Board of Trade that it has been called upon to enforce a particular system of traction upon any particular line, and as it seems to be generally accepted that the decision is a wise one, in the circumstances one fervently hopes that the two companies will act in greater harmony than hitherto and that the work of transformation will proceed with an acceleration of "one and one-half feet per second per second." The one morsel of comfort meted out to the defeated company is the statement in the report that the arbitrator was convinced that the District Company's method of procedure had been so embarrassing that the Metropolitan Company had no other option than arbitration. And for the present closes an *affaire* which will undoubtedly remain a landmark in the history of electrical progress in London. With a chivalry which costs nothing the technical press here is greatly sympathetic with Herr Blathy after his magnificent attempt, and his failure is due not to any inherent defect in his arrangements, but of the unfortunate British tendency to follow and not lead.

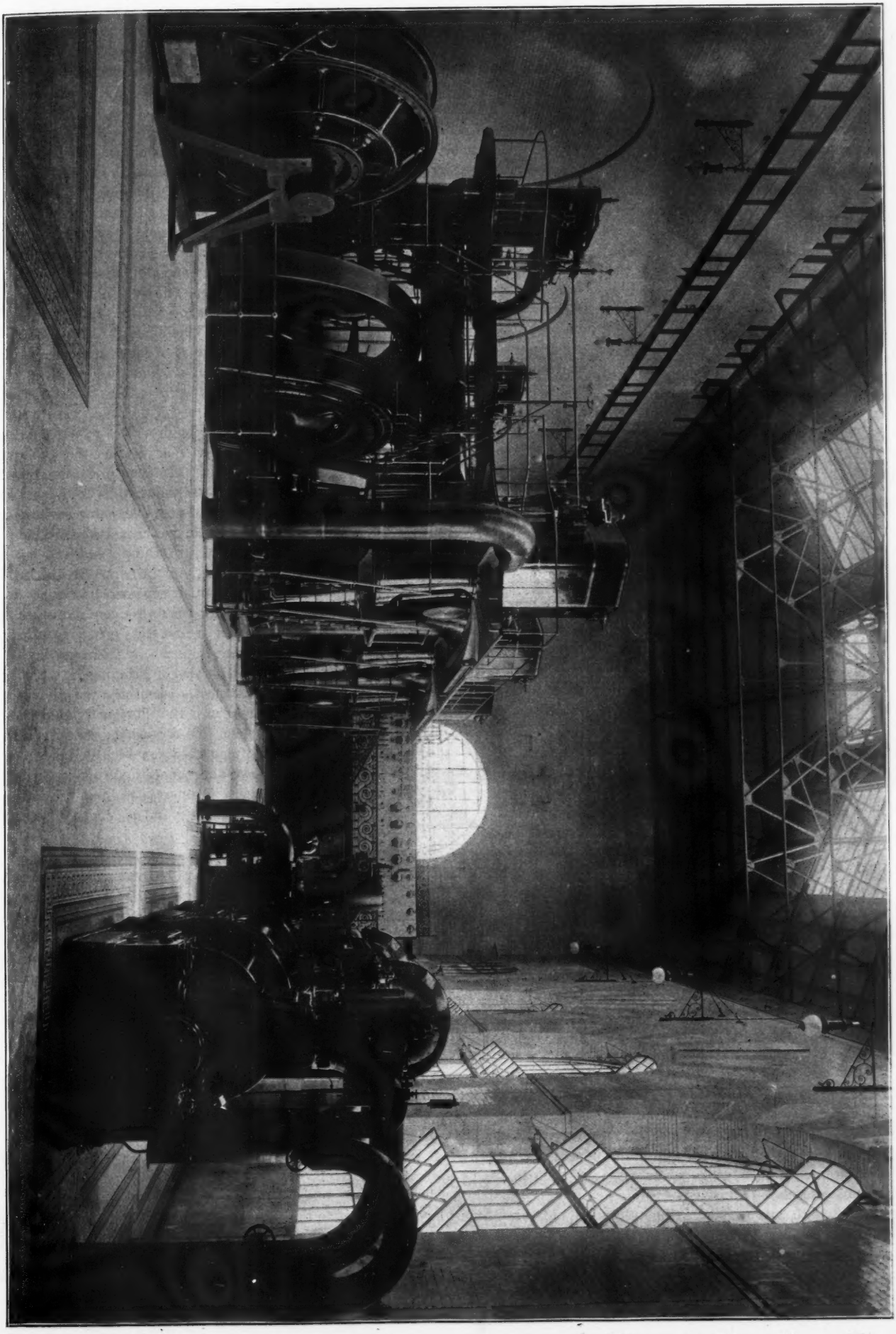
As has often been noticed in these latter day warlike times, every one is a patriot to his country until such patriotism begins to pull at his purse, an unpatriotic sentiment provoked by the action of the Manchester City Council in again giving a large contract for electrical machinery to a German firm which, as hinted at in the discussion at the council meeting, is probably tendering considerably lower at the moment owing to the well-known industrial depression in Germany. A £36,000 difference is a tremendous one, and no slur can be said to have been cast upon German manufacturers when the above reason is adduced. One can not possibly for a moment admit that the conditions of labor and other considerations are such as to enable our Continental neighbors to outbid us in such a manner for precisely the same machinery. The committee was appealed to to accept the lowest English tender from a patriotic point of view, but the temptation of such a small fortune as £36,000 was too great, and so away goes the contract to the "Fatherland." Incidentally it might be mentioned that the specification was for three-phase plant, a department in which we have admittedly made but small progress heretofore.

But the electrical industry as a whole has been given more rein during the past year or two than at any time during its history, and a glance at the events of the year 1901 at once justifies this statement. The past twelve months will have many interesting memories for Londoners. Did we not experience, for the first time, the joys of electric traction, thanks to the energy of the London United Tramways Company, of whose power-house a view is given in the illustration. Many electric supply stations have been opened and only two districts in London are not now blessed with an electric supply system. In fact throughout the country generally the progress made during the past year has been a memorable one and a happy inauguration of the twentieth century. The passing of the Pacific cable bill and the sanctioning of the high-speed monorail railway between Liverpool and Manchester are two worthy instances of what is taking place. Then the activity of the London County Council in electrical matters is bound to attract attention, and although its attitude recently in electrical matters is not applauded by every one, yet the good results achieved generally by the council at least enable one to view without undue anxiety its efforts in this latter domain. Everywhere except in London electric traction is forcing its way to the front and in Liverpool and Glasgow there are now over 100 miles of trolley tramways. In the metropolis Mr. Yerkes promises to shake us up ere long, and besides this, if the number of proposals go for anything, a similar upheaval should be witnessed simultaneously with and independent of that of Mr. Yerkes. The new National Physical Laboratory first started effective work during 1901, and affords another instance of an advance of a permanent nature. These few examples point to a busy time in the future, and judging by the present agitation being stirred up by the London Chamber of Commerce in favor of a general revision of the legislature regarding the electrical industry, we may well afford to view the next few years with a complacency hitherto somewhat foreign to our nature. Professor Perry once quite recently remarked that it was characteristic of the Anglo-Saxon race to depreciate itself. In electrical matters there seems of late years to have been a rather abnormal tendency in this direction, but in spite of the said tales of foreign competition, in many cases only too apparent, the fact remains that our own manufacturers of electrical goods are all busy and many find their present accommodation too limited for their demands, a healthy circumstance often wilfully overlooked by the croakers.

This question of municipal trading in the electrical industry is rather to the fore at the moment possibly on account of the lack of enthusiasm shown in so many instances in putting the powers obtained from Parliament by local authorities into effect. This is especially noticeable in the number of provisional orders granted by the Board of Trade during recent years which have simply been shelved, a process quite ample enough to keep out any effort to carry out the work by private capital. A paper was recently delivered before the London Chamber of Commerce by the chairman of its electrical section in which the author denounced this policy in emphatic terms. No one objects to municipal trading carried out on economic principles, but the composition of some local governing committees is obviously against such a policy, and the manner in which a company is refused facilities is, in many cases, a sufficient justification for such doleful discourses as the one just mentioned. Although many of them are without doubt extremely partisan, yet it is not difficult to realize the degree of retardation imparted to the electrical enterprise by legislative powers in the hands of local authorities.

A. W.

London, December 30, 1901.



Power-House of the London United Tramways Company (see opposite page).

THE CONSTRUCTION OF SMALL TELEPHONE EXCHANGES—XXI.

BY A. E. DOBBS.

SHORT TOLL AND PARTY-LINE DEVICES.

We take it for granted that most of our readers know the difference between series and bridging party lines, but before passing the subject it will be just as well to stop and make a comparison of the two, for both possess advantages and disadvantages peculiar to themselves.

The series grounded line, for example, has many advantages. First it is a simple circuit, one not liable to get in trouble, or, if it should do so, the trouble is easily located and cleared; should there be a ground on the line the stations each side of the trouble can still communicate with each other. Should the line be broken, the intelligent use of a ground wire will still enable it to be used in sections. The objections to it are:

First—All the ringer magnets are in the line circuits, which distorts the electrical waves to such an extent that conversation is apt to be very bad. Thus, though a line containing ten series magnets may measure, say, 1,000 ohms when tested by *direct*-current galvanometer, yet its impedance or resistance to an *alternating* or *intermittent* current, vibrating at the rate of from 500 to 5,000 times per second—such as telephonic impulses are resolved into—becomes equal to many times 1,000 ohms.

Second—There are also the switch-hook contacts to be considered, which may become a source of considerable trouble, for a weak spring contact is, to say the least, only reasonably reliable, and it is to be regretted that the lower contact spring does not always receive the attention it should, which constitutes one of the greatest annoyances with a circuit of this kind because it makes it possible for oxidation at the points of contact, a grain of dust or a loose contact to open the line. The failure of many lines of this kind is due to the fact that the same care is not taken with the lower as with the upper hook contacts.

As to the first objection, this can be overcome by the use of condensers, or by the use of non-inductive resistances around the ringers, as shown in Fig. 86.

In one case the waves are transmitted by induction through the condenser in something like their original form, as, with a properly proportioned condenser—say, 0.75 microfarad capacity—the wires will meet with less resistance than they would in passing around the magnets. In the other case we have a resistance coil of non-inductive form—as, say, a coil of German silver wire, with a resistance of three to five times the resistance of the magnet spools—which gives the current two paths, one around the ringer and one through the shunt coil. This does not prevent the magnets receiving the larger part of the current when ringing, but when waves of from 2,000 to 3,000 impulses per second pass over the wire, they will take the non-inductive path in preference to passing through the magnet spools.

One of the practical troubles attached to these devices is that while they are a decided improvement to a line of this kind, yet both are quite susceptible to lightning discharges and the trouble can only be ascertained by testing either the condensers or the resistance spools by a personal visit, as the effect may not be noticed at first except by a slight deterioration of the talking service.

With bridging lines the system is not quite so simple. Should there be trouble in the instrument, the circuits being more complex are harder for the troubleman to follow. If the line should be a grounded one there is some wire saved in making the connection from the highway to the house or station, there being in that case only a single wire, but this economy of wire is, however, made up in the additional cost of the instrument.

Should the line be a metallic circuit and become crossed it is almost impossible to locate the trouble by testing, but it must be found by going over it on a tour of inspection. It might be added, however, that when there is trouble on the line a man generally has to drive over it anyhow.

Should the line become crossed or grounded anywhere, it generally puts the whole line out of service till it can be repaired. Should the subscribers take down their receivers to listen it becomes difficult to call either the exchange or the party wanted. In case of a break, however, unlike a series line, the subscribers on either side of the break can still communicate with each other.

The only advantage of the bridged line, therefore, lies in the fact that the ringer magnets are not included in the talking circuit, as they merely constitute leaks across the circuit which cause a loss of only two or three per cent of the total current at each instrument. With a series instrument the voltage rises in direct proportion to the number of instruments in circuit. With a bridged line the quantity of current must be proportioned to the number of instruments. In the first case the size of the field magnets is not increased to meet the demands for this increased voltage, but the number of turns of wire on the armature is increased so that a series generator rarely contains more than three magnets to energize the armature, even though it is made to ring through 50,000 ohms.

With bridging ringers and generators, where it is necessary to place a great many of them on a line, the size of the ringer spools must be increased to accommodate the extra wire necessary to increase the self-induction and resistance which prevents loss of the current through leakage. Then the generators must not only ring a large number of bells in multiple, but must ring them over a line resistance of from 2,000 to 3,000 ohms. All this means that the armature of the generator must be increased in size and wound with coarser wire to give the current necessary for this work. Moreover, the field strength must be increased in order to give the necessary voltage, so that we find the number and size of the permanent magnets greatly increased. In many cases this makes necessary a considerable enlargement of the box and further increases the cost.

In spite of these disadvantages, however, bridging instruments are the only kind seriously considered for party or toll-line work where the conditions are at all difficult or first-class service required. To prevent subscribers from putting a line out of service by listening in, a 1,000-ohm resistance is sometimes placed in the receiver circuit. Personally, however, for farmer line service the writer would use the plan shown in Fig. 86, taking care to make the connections inside the box in such a manner as to leave the shunt coil or condenser independent of the switch hook contact.

The shunt coils shown will take away a proportion of current from the ringers, so that a generator which might ring another eighty-ohm bell through 10,000 ohms resistance would not ring the same bell through a resistance greater than about 4,000 ohms when part of the current is diverted by means of a 300-ohm shunt.

A condenser would probably be more satisfactory than this shunt, but it would take up so much room as to make it necessary to place it outside the instrument.

FARMERS' LINE CONNECTIONS.

We have before this spoken of the undesirability of connecting to many of the home-made farmer lines scattered throughout the country, but if the line is in fair condition they form a welcome addition to many small exchanges, even though they may not be perfect either in construction or operation.

In many parts of the country farmers

have built lines from fifteen to thirty miles in length, and perhaps they average an instrument for every mile of the way. When this is the case, and connection is

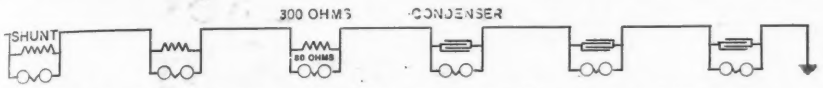


FIG. 86.—TWO METHODS OF BRIDGING AROUND THE RINGERS IN A SERIES LINE.

desired with the local exchange, they should be compelled to place their lines under the control of the exchange and pay rental for the connections, taking pay

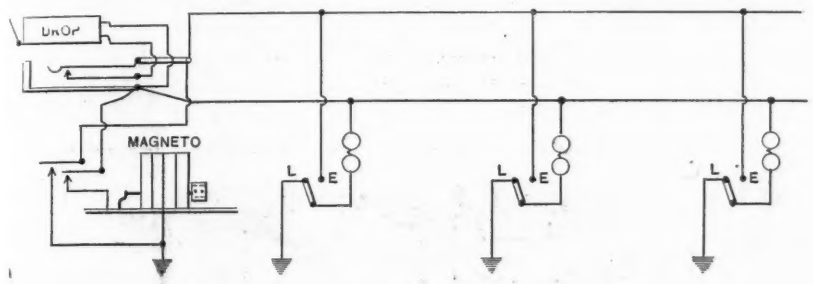


FIG. 87.—LOCAL AND THROUGH LINE COMBINATION.

for their lines in stock or cash according to circumstances. In a case of this kind the subscribers will wish to ring each other a great deal and, as it becomes difficult for the operator to distinguish the various signals, there should be some

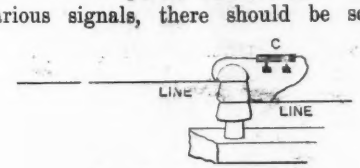


FIG. 88.—TEST JOINT.

method of selective ringing. To obviate this trouble a second wire may be run out alongside the first, but not connected with it except through a local switch placed at each telephone.

When farmers wish to call each other, they simply ring over the grounded line without disturbing the exchange, the switch being on the local point L (Fig. 87). Should they wish to call the ex-

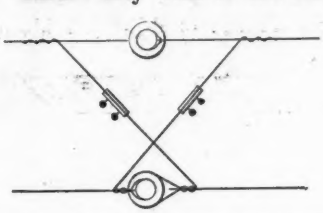


FIG. 89.—TEST JOINTS AT TRANSPOSITION POLE.

change, however, they throw the switch to the right, E, which connects them by metallic circuit with the drop. Should they forget to return the switch to the local side, "Central" could still call through the metallic circuit, though ordinarily she rings through the ground. Furthermore, this ensures secret calling to the exchange, while exchange and local calls do not interfere.

TEST STATIONS.

It is very desirable that long lines should contain test stations or places where the line can be opened occasionally for testing purposes, for it often happens that a trouble will be overlooked in passing over the line. Moreover, it is sometimes a convenient saving of time to take a street car and make the first test several miles from town.

One of the simplest methods is shown in Figs. 88 and 89. In one case the wire is simply opened on the insulator and the two ends brought together by means of a connector, *c*, such as is frequently used in electric light work, the wire being held in place by means of binding-screws. One end of this connector may be soldered to

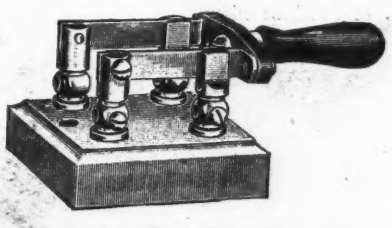


FIG. 90.—BABY KNIFE-SWITCH.

the wire to ensure a firmer contact and the other held by means of the binding-screw. To make a test, the lineman goes up the pole, opens the wire at his connector, after which he can easily test in either direction, or both, with a testing telephone set.

Fig. 89 shows the same thing, except that there are two connectors applied at some transposition point. Both these connectors should be opened if the test is to be made for a "ground," but it is only necessary to open one when testing for a cross. With toll lines, however, it is generally more convenient to place these test stations at spots where the tests can be made at the telephone stations, provided they are not too far apart. In the first place, secure three baby knife-switches, such as are shown in Fig. 90, mount the three in a box to be placed on the side of the pole, the box to be locked by a key kept at a house near-by.

Some one around the station should be instructed in the use of these switches,

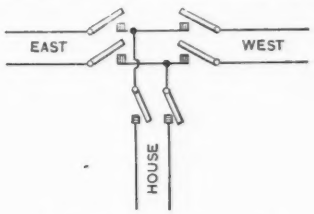


FIG. 91.—TEST SWITCHES.

which are connected as in Figs. 91 and 92. Should the switch on the left side be opened, the house telephone is then connected to the right, and *vice versa;* opening the middle switch cuts the house telephone off the line should trouble be found in that direction.

In Fig. 92, however, an ordinary circuit-changing switch is used in the house connection, which can be switched either to the east or west side when the line switch is open.

The box containing these switches should be placed high enough to be out of the reach of mischievous persons and the wires leading to it covered up to a distance above the ground, and the best duplex rubber-covered wire used to make the connection.

The person in charge of this station should be instructed to make tests whenever he discovers any trouble on the line, and, by getting one end or the other, report to headquarters.

The box containing these switches should be water-tight and shallow enough so that the door can not be closed while the switches are open, in order to prevent forgetfulness on the part of the attendant.

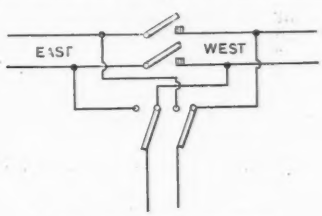


FIG. 92.—TEST SWITCHES.

With this system in use, trouble can readily be tested from one station to another till it is located between two of them.

Connections to these switches should be soldered.

The phenomenon of osmosis has been turned to account by Dr. Graf Schwerin, of Munich. Patents have been taken out for the extraction of moisture from such materials as peat, wood pulp, etc.

The Generating Station and Distributing System of the Manhattan Elevated Railway in New York City.

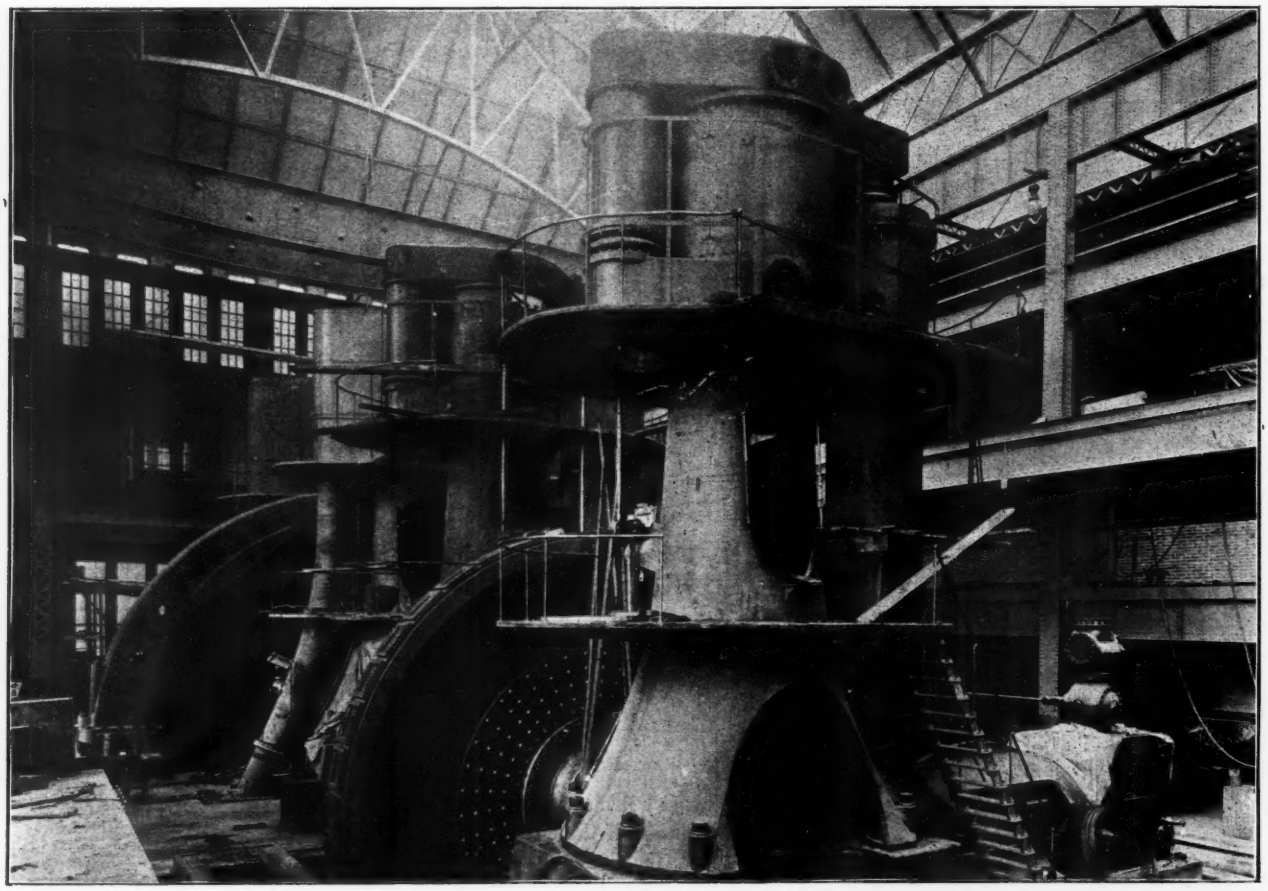
THE work of equipping the elevated railway system of New York city with electric traction has now progressed to such a point that one line —that on Second avenue—is about to be opened for service and it is expected that the others will very shortly follow. The equipment of this important system of railways is in many ways a notable achievement and the design adopted reflects, in a high measure, credit upon all who were concerned in its development.

The work involved in the substitution of electricity for steam on these lines has included the equipment of a large number of trains, the erection of an enormous generating plant, the installation of high-pressure transmission lines to numerous substations and the elaboration of a system of lighting and motive power for the trains, yards, platforms, stations, offices and shops of the company.

THE GENERATING STATION.

The central generating station of the company is a building 205 feet wide by 395 feet on one side and 413 feet on the other, situated on the water-front at the foot of Seventy-fourth and Seventy-fifth streets, on the East River, in the Borough of Manhattan. The maximum capacity of the plant is 80,000 horse-power.

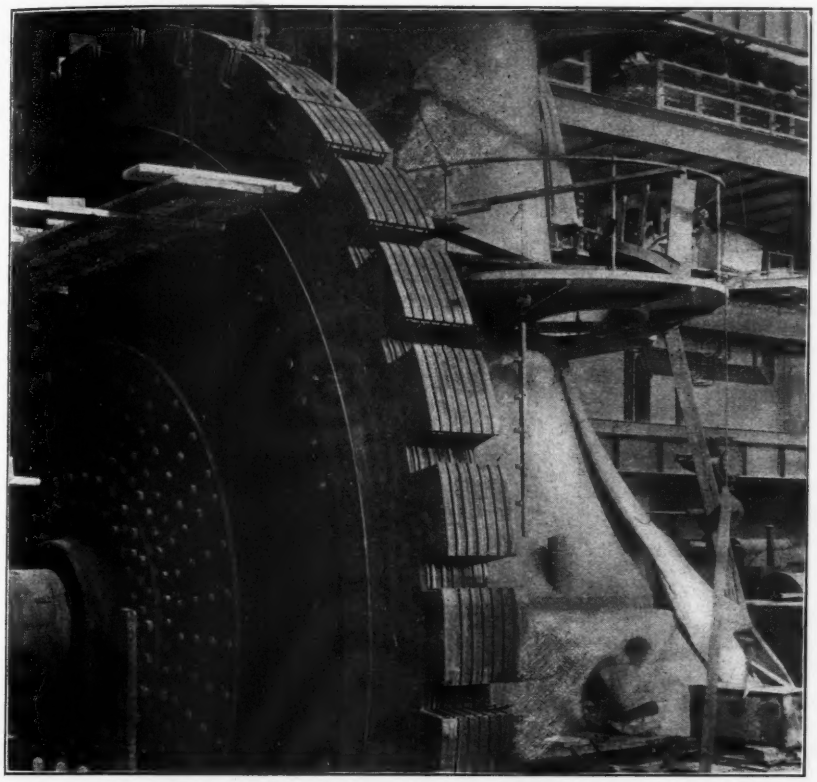
The building is longitudinally divided by a brick fire wall, the boiler equipment being placed on one side and the engines and dynamos on the other. The quipment consists of eight units, each of which is complete in itself and practically independent of the others. Each of these units consists of four batteries of boilers, one condenser, the necessary boiler feed pumps and piping, one engine and one alternator. Each unit has a boiler capacity of 4,200 rated horse-power of Babcock & Wilcox horizontal water-tube boilers, arranged to operate at nearly 200 pounds steam pressure. The Roney type of mechanical stokers is used on the boilers, it being estimated that these machines will save the labor of 180 men in stoking. The 256 stokers which have been installed under the sixty-four boilers are capable of developing fifty per cent above the rated capacity of the latter. When this boiler plant is finished it will be the largest ever designed or installed.



ONE OF THE 5,000-KW. UNITS IN THE MANHATTAN RAILWAY COMPANY'S STATION.

Fuel economizers of the Green type are employed in the headers carrying the hot gases from the boilers to the smokestacks; sixteen of these machines being installed. They are of the high-pressure type and aggregate a total of 8,192 tubes.

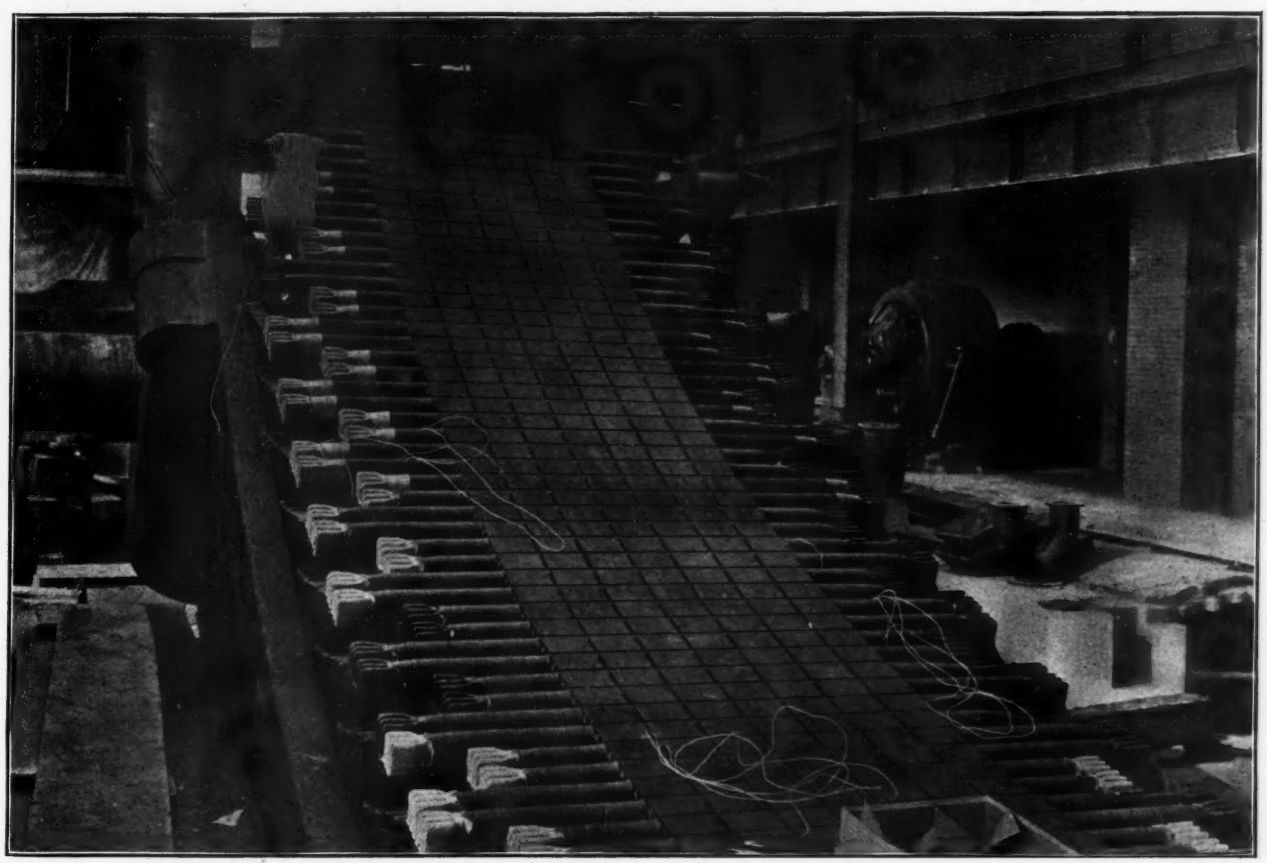
The smokestacks are one of the most imposing features of the structure. They are four in number, seventeen feet in diameter inside and 278 feet high above the mean tide level of the East River.



PART OF THE REVOLVING FIELD OF A MANHATTAN 5,000-KW. ALTERNATOR.

The stacks are of the Custodis type, constructed of sector-shaped bricks, and are among the finest structures of this kind in the world. While their dimensions are sufficient to furnish all ordinary draft requirements, sixteen blowers of the Sturtevant company's type have been installed to furnish forced draft should this be needed. These blowers are operated by polyphase motors. The boiler pumps, of the triplex single-acting Gould type, are eight in number, each being direct coupled with a 500-volt direct-current motor. The most interesting feature, perhaps, of the installation is the magnificent generator units, each consisting of a 5,000-kilowatt Westinghouse revolving field alternator, direct coupled with an Allis-Corliss combined vertical and horizontal engine. These units have a nominal or economical working rating of 5,000 kilowatts, with a maximum capacity of 7,500 kilowatts, and are the largest electrical generators that have ever been erected.

The steam engines were designed by Mr. Edwin Reynolds and built at the Allis shops in Milwaukee. The engines are of an unusual type, the two high-pressure cylinders being vertical and the two low-pressure cylinders horizontal, thus making the machine effectively a pair of compound engines. The cylinders are, respectively, forty-four and eighty-eight inches in diameter with a five-foot stroke,



PORTION OF THE ARMATURE OF 5,000-KW. ALTERNATOR, SHOWING METHOD OF WINDING.

and the machines are adapted to run at seventy-five revolutions per minute. The engines have a maximum capacity of 12,000 horse-power. The cranks are set so that the shaft receives eight impulses per revolution, making the turning effort so uniform that the flywheel effect of the rotating field of the alternator is sufficient for steady revolution. The arrangement also prevents any dead centre and enables the engine-man to start these gigantic machines without paying attention to the point at which they have stopped. Steam jackets are not used, but the valves are placed in the heads of the low-pressure cylinders, making a partial jacketing effect. The Reynolds-Corliss valve gear is employed, with separate eccentrics for the steam and exhaust valves of each low-pressure cylinder. The two sides of the engine are entirely distinct, and one can be run with the other uncoupled, if so desired, without affecting the steam efficiency of the machine.

The steam pipes leading to these engines are fourteen inches in diameter, the effective pressure at the cylinder being 150 pounds per square inch. A separate intermediate receiver is provided for each side of the engine, each of these containing 773 square feet of two-inch copper tubing, filled with boiler steam, as a reheating surface. The exhaust pipes leading from these engines are forty inches in diameter, each unit being piped to a separate condenser.

The pistons are rectangular in cross-sections with bull and packing ring and follower, all heavily ribbed, screwed on to the rod with a jam-nut and keeper. The rods are all eight inches in diameter, of open-hearth steel, screwed into the cross-head as well as into the piston. The Allis-Reynolds cross-heads have been modified, and provision made for fastening the babbitt-lined shoe to the body of the cross-head in addition to the usual studs of the adjustable wedges. The connecting rods of the vertical and horizontal engines are of the same length—5.4 cranks. They are of open-hearth forged steel, with a solid end in the cross-head and strapped at the crank-pin end. The cross-head pins are twelve by twelve and the crank pins eighteen by eighteen, or nine by eighteen inches for each rod.

The dynamos are machines of extraordinary interest. They are wound to deliver three-phase current at 11,000 volts normal, which may be raised to 12,000 volts if necessary. The wave form is very nearly a true sine curve under all conditions of load and power-factor, and the regulation between no load and full load is within six per cent. The rise in temperatures under full load for twenty-four hours does not exceed thirty-five degrees centigrade and at fifty per cent overload will not exceed fifty-five degrees centigrade. The efficiency at full load from engine to switchboard is 96.5 per cent.

Mr. L. B. Stillwell, the consulting engineer of the Manhattan company, calls attention to other distinctive features in the design and construction of the equipment that may be summarized here with profit:

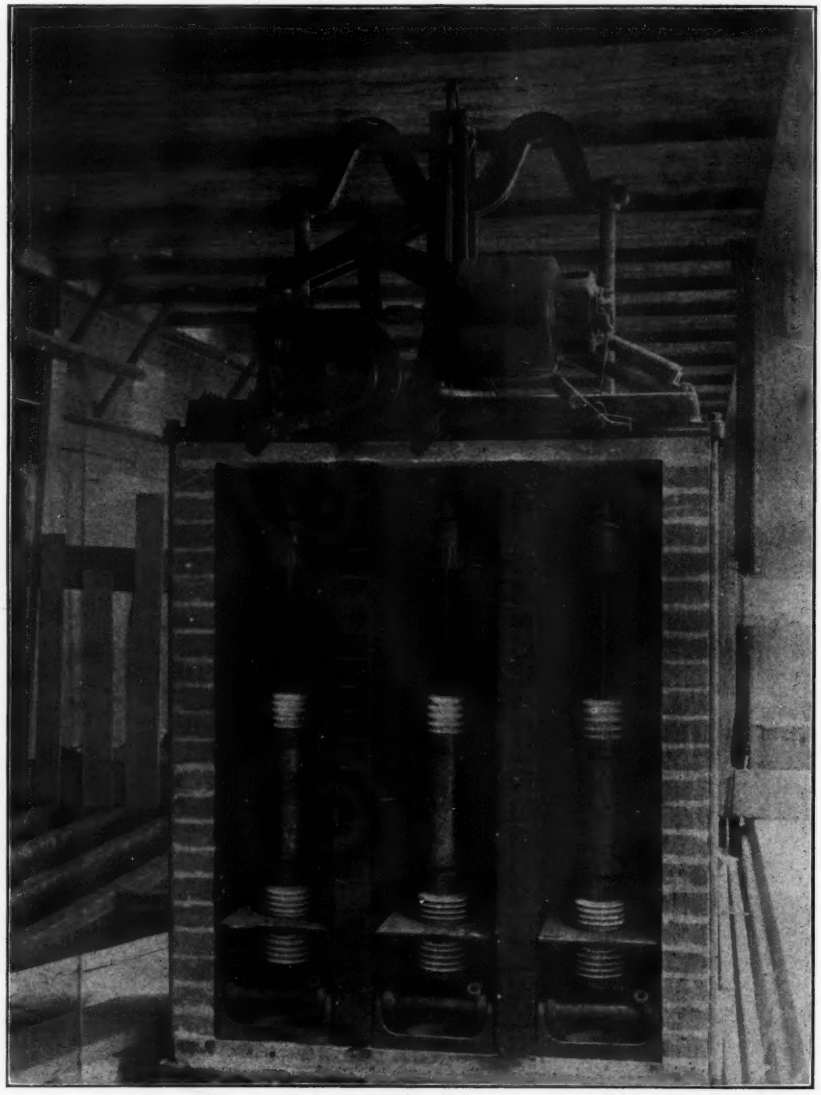
"Uniformity and symmetry in organization and arrangement of apparatus, both in power-house and in substations, it is believed, will facilitate future extensions and secure advantages of simplicity in construction, and, more especially, in operation.

" The design of the engine-dynamo unit eliminates the usual auxiliary flywheel. The weight and dimensions of the revolving dynamo field are such, with reference to the turning moment of the engine, that any auxiliary flywheel is unnecessary.

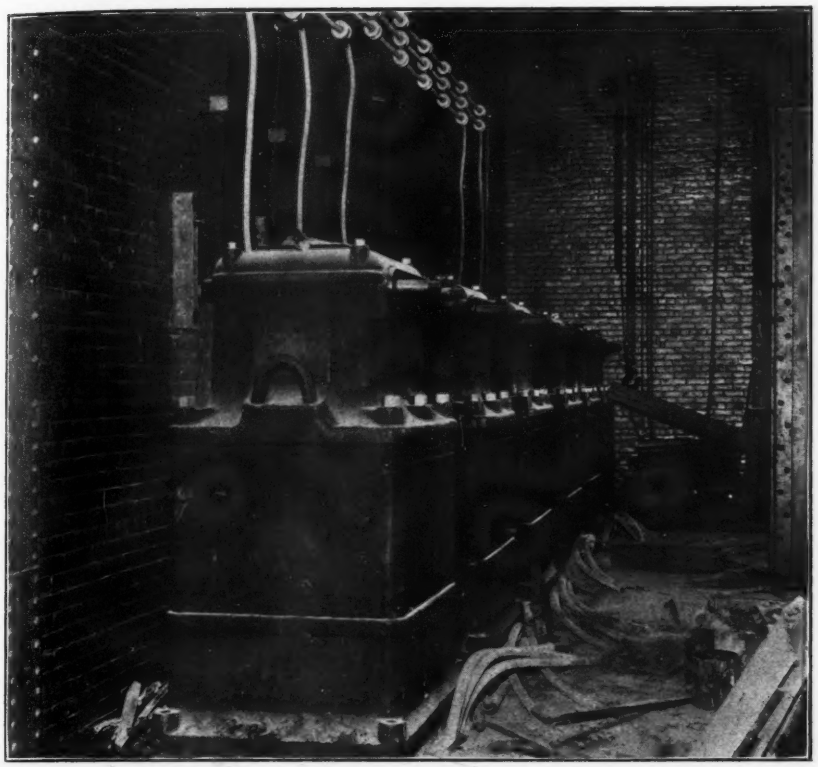
"The revolving parts of the dynamos are particularly designed to secure very unusual strength and consequent ability to resist the tendency to burst and fly apart in case of temporary abnormal speed through accident of any kind. The hub of the revolving field, which is also the flywheel of the engines, is of cast-steel, and the rim is carried not by the ordinary spokes but by two webs of rolled steel.

"The angular velocity of the revolving field, as determined by the relation of flywheel effect and torque or turning moment exerted upon the shaft by engine pistons, is uniform to an extraordinary degree.

"Especial effort was made to attain



DETAIL OF ONE OF THE 11,000-VOLT MOTOR-CONTROLLED OIL SWITCHES IN THE MANHATTAN RAILWAY COMPANY'S STATION.



A Group of 555-kw. Transformers in Substation No. 5, Manhattan Railway.

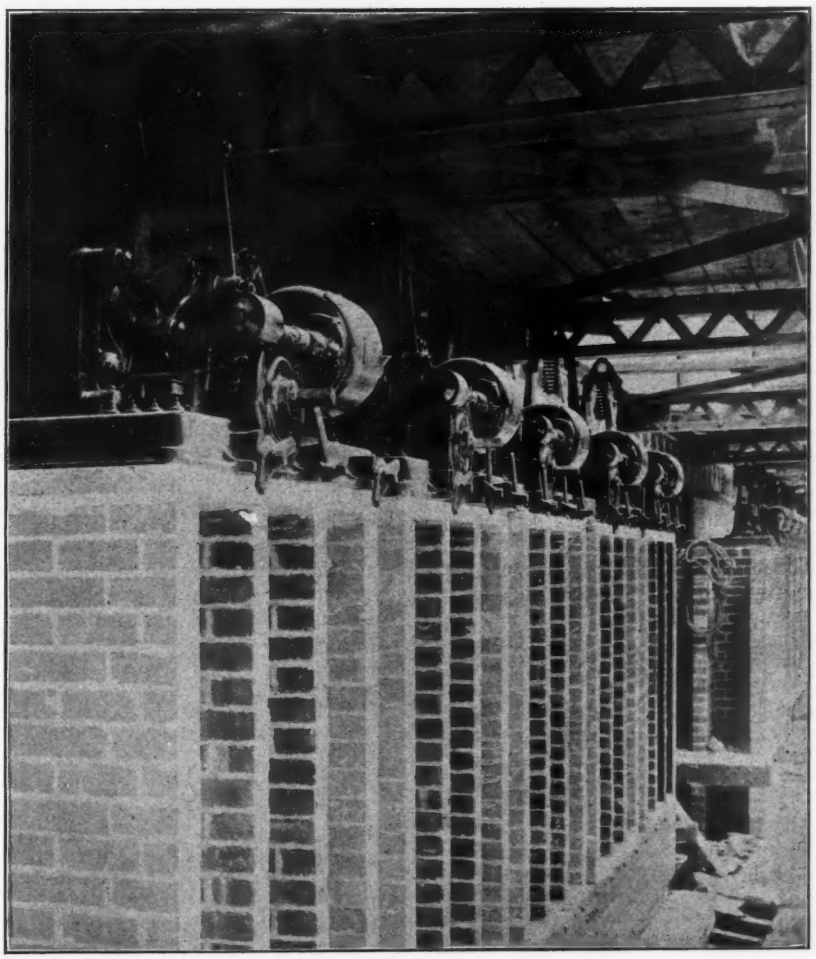
close approximation to the theoretically perfect form of the 'potential curve'—'wave-phase'—through a half cycle, that is, the sine curve, the armature being so wound as to provide four conductors per phase per pole."

The machines are of the revolving field type, the field magnets with their windings forming the rim of a great wheel which is attached by web plates of rolled steel to a cast-steel hub directly keyed upon the engine shaft. The revolving field is thirty-two feet in diameter, part of it being excellently shown in one of the accompanying illustrations. At seventy-five revolutions per minute, which is its rated speed, the periphery runs at 7,540 feet a minute. The revolving field weighs 370,000 pounds.

There are forty field poles, built up of laminated steel. They are wound with copper strap on edge, one layer deep, and the insulating material is cemented in place between the turns. The edges of the strap are exposed in order better to dissipate the heat developed. The normal exciting current for each alternator field is approximately 225 amperes at 200 volts, and the winding is so designed that the excitation can be increased to care for an overload of fifty per cent and a ninety per cent power-factor. The field windings are held upon the poles by copper wedges driven between the pole tips.

The armature, which is the stationary member of the machine, consists of six heavy castings, to which the laminated plates are attached. A portion of the armature, in process of being wound, is shown in one of the illustrations. The winding is composed of insulated copper bars, and the laminated armature plates are separated at intervals by ventilating spaces, through which a constant stream of air is blown by the centrifugal action of the rotating field.

The winding is of the distributed type with four slots per phase per pole. It was regarded as specially important to design these machines for as smooth a wave form as possible, in order to prevent the possible detrimental effect of harmonics, in view of the great capacity and self-induction of the immense system of cables and transmitting apparatus connected with these machines. This precaution was also necessary, in view of the large number of rotary converters employed. Each slot of the winding contains three bars, any of which may be removed without disturbing the bars in the other slots and without moving the frame of the machine. The insulation of



Group of Motor-Controlled Oil Switches in the Manhattan Railway Company's Power Station.

these conductors is such that it will withstand a puncture test of 25,000 volts for half an hour.

These dynamos being by far the largest that have ever been constructed, some interesting questions came up in their design in regard to transportation of parts and facilities for handling and assembling. The great works of the Westinghouse Electric and Manufacturing Company, at Pittsburgh, where they were built, are well equipped with the large tools and heavy handling machines necessary, but it was found necessary to build special freight cars for hauling the parts to New York, and also to take into account, in the design, the clearance of tunnels, bridges, etc., along the lines of railroads over which these parts had to be shipped. The dynamos were assembled for the first time when they reached New York and tested out satisfactorily. This is regarded as no small achievement. The weight of each complete machine is 900,000 pounds and the height of the machine is forty-two feet.

The exciters for these immense machines are four in number, each of 250 kilowatts capacity, and are of the Westinghouse direct-current type. These exciter machines are each driven by a direct-coupled engine. Rotary converters and transformers will be installed at the central power station to furnish direct current for operating the motors and lighting plant.

THE DISTRIBUTION SYSTEM.

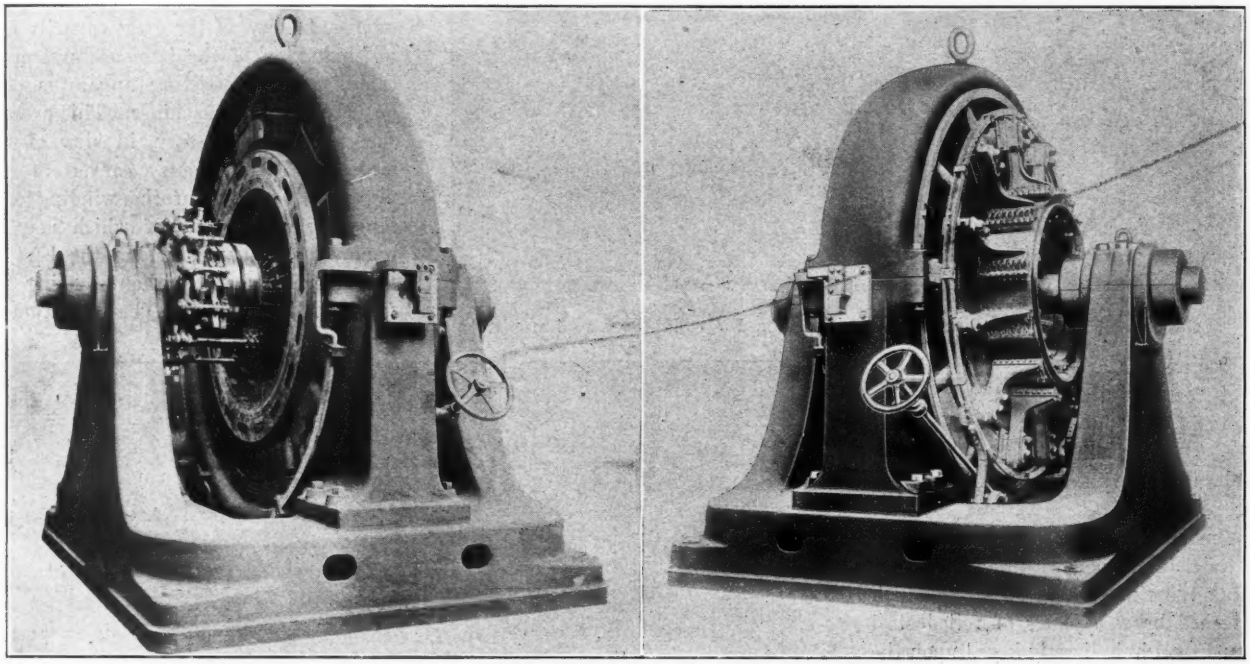
The lines of the Manhattan Elevated Railway include thirty-seven miles of road in the boroughs of Manhattan and the Bronx. Eight substations have been erected along the lines, in each of which is installed the necessary transforming apparatus for reducing the voltage to a proper point and transforming the current to direct current for supplying the third rail. These substations have been erected upon a uniform design, this feature of uniformity, as commented upon in Mr. Stillwell's remarks above, being marked throughout the entire installation.

The converters are arranged in two parallel rows and the transformers are located in groups of three in galleries along the sides of the substations. In the various substations there are twenty-six rotaries and seventy-eight transformers. A group of these transformers is shown in one of the illustrations. The transformers are rated at 550 kilowatts capacity, connected in delta, and furnish approximately 390 volts in their secondary circuits. On account of the different distances from the power stations at which the substations are located, and the fact that all of them are fed from alternators operated in parallel, the effective potentials delivered by the high-pressure distributing cables to each is different. Provision for adjustment of the ratio of transformation of the step-down transformers to offset this difference has been made in each case. The transformers are of the air-cooled Westinghouse type, with motor-driven blowers for each group. Their guaranteed efficiencies are 97.75 per cent at full load.

The rotaries are the largest that have yet been constructed, having a nominal rating of 1,500 kilowatts each and a maximum capacity of 2,250 kilowatts each. Each is a self-contained unit. They are of the twelve-pole type and operate at 250 revolutions per minute under the twenty-five-cycle current with which they are supplied. The field is compound-wound, the shunt winding being arranged for self-excitation. The direct-current output is at 625 volts, and the guaranteed efficiency at full load is 95.75 per cent. The armature is of the slotted-drum type, the winding consisting of strap-wound coils formed and insulated before being placed in position. The winding is of the parallel type, in twelve circuits, and is cross-connected by appropriate balancing rings. The average limit of potential between commutator bars does not exceed twelve volts. The various features of the construction of these machines are clearly shown in the accompanying illustrations.

The field frames are of cast iron and the field pieces are laminated, the faces of the latter being beveled to allow the use of copper shields. The series field is sufficient to compound the direct-current voltage from 575 to 625 volts between no load and full load. The series winding is of strap copper, wound on edge. The makers guarantee the rotaries to stand 100 per cent overload without falling out of step or hunting. Each of these machines is thirteen and one-half feet high. The starting of these immense converters is accomplished by direct current furnished from starting sets, each consisting of a direct-current dynamo driven by a three-phase induction motor.

All of the direct current generated at these substations, having a maximum total capacity of 55,000 kilowatts, is fed to the third rail and feeder system, upon which the traction motors are operated.



Showing Collector Ring End. Showing Commutator End.

TWO VIEWS OF ONE OF THE 1,500-KW. ROTARY CONVERTERS FOR THE MANHATTAN RAILWAY.

The first official trial of the electrical service on the Manhattan Elevated Railway was made Thursday afternoon, January 9, just as this issue of the ELECTRICAL REVIEW goes to press. The trial trip was attended by officials of the railway company, press representatives and others, and was successful throughout.

The Personnel of the New York Rapid Transit Subway Work.

On this page is shown a group photograph of the engineers and contractors for the New York Rapid Transit Subway, now being constructed in Manhattan Island and the Borough of the Bronx.

It is interesting to note that this group of men has in charge the most important piece of electric traction work now in process of construction anywhere in the world. It is believed that the investment represented by this railway, when it is completed, will be in excess of fifty million dollars, while the difficulties that have been encountered and are still to be met in its construction are probably greater than those of any other similar undertaking anywhere.

Mr. John B. McDonald, to some degree the moving spirit of the enterprise, and general contractor for the entire work, has exhibited in this undertaking an example of the same spirit that overcame difficulties and overrode obstacles in the construction of the Atlantic cables or the transcontinental railroads. Nowhere else has the building of an underground line for city transportation encountered such natural and artificial difficulties as exist in New York city. The character of the rock through which much of the work has to be driven, the tangled and complicated maze of pipes and subways which occupy portions of the ground immediately under the surface, the height and weight of buildings along the narrow streets through which some of the tunnels must run, and other difficulties too numerous to mention, would have deterred any but the boldest spirits from such an undertaking.

The engineering side, however, of the subway work has been scarcely less important than the financial and executive branch of the work. Although no announcement has yet been made of the type of electric traction that will be used in the subway, it is understood that this will be a direct-current system with very rapid acceleration, permitting high overall speeds.

JOHN VAN VLECK. H. T. DOUGLAS. S. F. L. DEYO. E. P. BRYAN. JOHN B. McDONALD. L. B. STILLWELL. A. E. OLMSTEAD. FREDERICK EVANS.

ENGINEERS AND CONTRACTORS FOR THE NEW YORK RAPID TRANSIT SUBWAY. Photo by P. P. Pullis.

The gentlemen in the front row of the photograph, from left to right, are: General Henry T. Douglas, principal assistant engineer; Mr. S. F. L. Deyo, chief engineer; Mr. E. P. Bryan, general manager of the Rapid Transit Railway Company; Mr. John B. McDonald, general contractor for all the subway work; Mr. L. B. Stillwell, electrical director; Mr. A. E. Olmstead, division engineer, and Mr. Frederick Evans, secretary. At the extreme left, behind General Douglas, stands Mr. John Van Vleck, mechanical engineer. The photograph was taken in the draughting room of the offices of Mr. McDonald, on the thirtieth floor of the Park Row Building.

A Dinner and Reception to Mr. William Marconi.

The American Institute of Electrical Engineers will give a dinner and reception to Mr. William Marconi at the Waldorf-Astoria Hotel, New York, at seven o'clock, Monday evening, January 13, 1902. A number of guests have been specially invited to meet Mr. Marconi, among them Professor Alexander Graham Bell, the inventor of the telephone. Several gentlemen will speak, among them Dr. Michael I. Pupin and Professor Elihu Thomson. The event will take the form of the annual dinner of the Institute, Mr. Marconi being the guest of honor. It is expected that ladies will attend the dinner.

Mr. Marconi is expected to arrive in New York on Sunday, January 12, and to remain a few days before sailing for England, where he will continue his experiments on long-distance wireless telegraphy.

Telegraphic Code for East and South Africa.

The manager of the Western Union Telegraph Company, at Washington, has stated that the "unicode" has been deposited by the British Government at Aden and Cape Town and may be used in addition to the codes already notified for messages to and from Cape Colony, Natal, Rhodesia, Seychelles, Mauritius, Madagascar, British and German East Africa, Mozambique and Lourenço Marquez.

A Model Independent Telephone Exchange.

The Fine Central Office of the Columbus, Ohio, Citizens' Telephone Company.

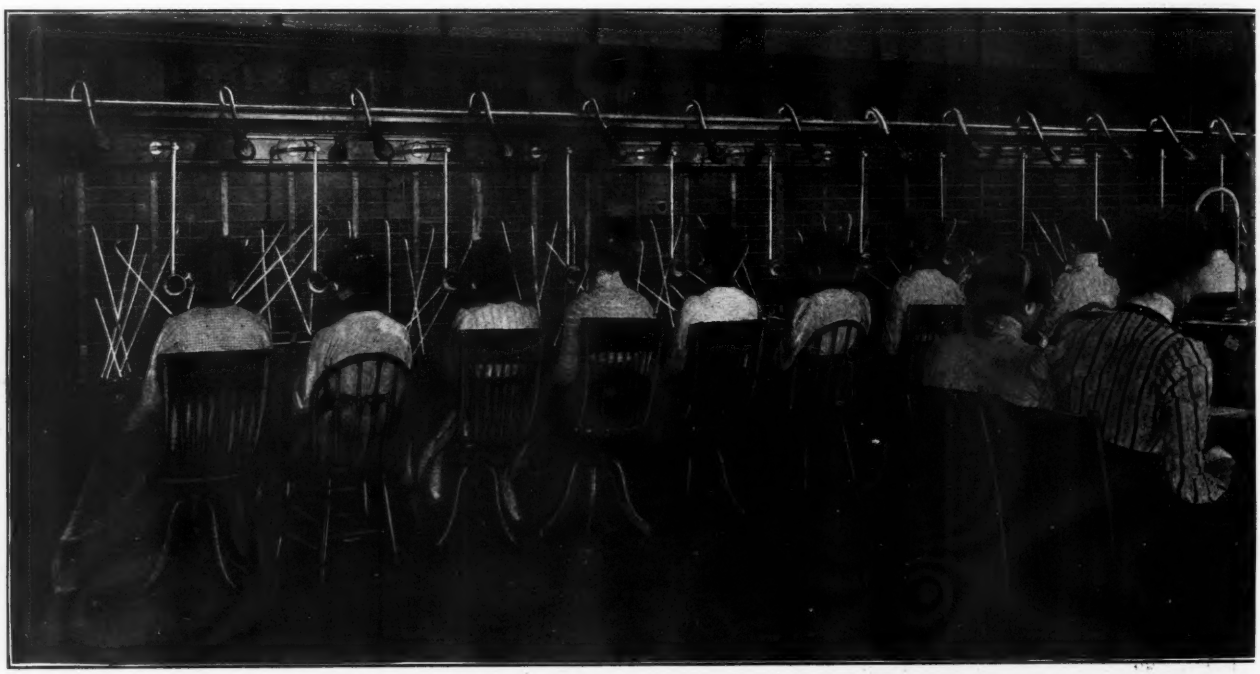
ON these pages are shown illustrations of the operating room of the main central office of the Columbus, Ohio, Citizens' Telephone Company, one of the finest independent telephone exchanges in the United States.

The immediate capacity of the full multiple switchboard is 5,440 main lines, while the capacity of the company's subways, laid under the streets in the underground district of the city, is for 12,000 lines. At present there are 5,420 main line subscribers with a total number of telephones in service of very nearly 6,000. On account of the rapid growth of the plant contracts have already been let for additional switchboard facilities to accommodate 2,400 lines in addition to the present capacity.

The exchange is located in a very solidly constructed building erected for the purpose and occupies all of the third and fourth stories and a large part of the second floor. The ground plan of the building is eighty by ninety-two feet in size, while the company's warehouse and storage place for poles, wires, construction material, etc., are on a separate plot of ground. The system in use throughout is that of the Kellogg Switchboard and Supply Company, of Chicago. The cables are of the filled paper type, manufactured by the Standard Underground Cable Company, of Pittsburgh, Pa., and the method of operation is upon the so-called central-energy system, in which the battery power necessary for operating the exchange is concentrated at the central office. A total of 140 operators is employed and these answer an average of somewhat more than 75,000 calls per day.

Radiating from Columbus as a centre are seven trunk lines of the United States Long-Distance Telephone Company, giving connection with substantially all of the independent telephone stations in the state and also connecting with points in the states of Kentucky, West Virginia, Pennsylvania, and through Michigan as far as Saginaw and Bay City. Twenty thousand telephones in Indiana are also reached, and at present over 150,000 telephones are capable of being connected with this exchange by means of the long-distance lines mentioned above.

It will be noted from the illustration that this main operating room is very large and well arranged, the switchboards running around two sides, while the monitors and chief operators are located at desks in the middle of the room. The exchange reflects great credit upon its constructors and upon the company whose operations have been entirely successful. The officers of the Columbus Citizens' Telephone Company are as follows: President, Mr. Henry A. Lanman; secretary and treasurer, Mr. Edwin R. Sharpe; general manager, Mr. Frank L. Beam. The directors are Messrs. Henry A. Lanman, Edwin R. Sharpe, Henry A. Everett, James M. Thomas, Wm. A. Hadesty, John Joyce, James B. Hanna, James B. Hoge, and H. D. Critchfield.



A General View of the Central Office of the Columbus

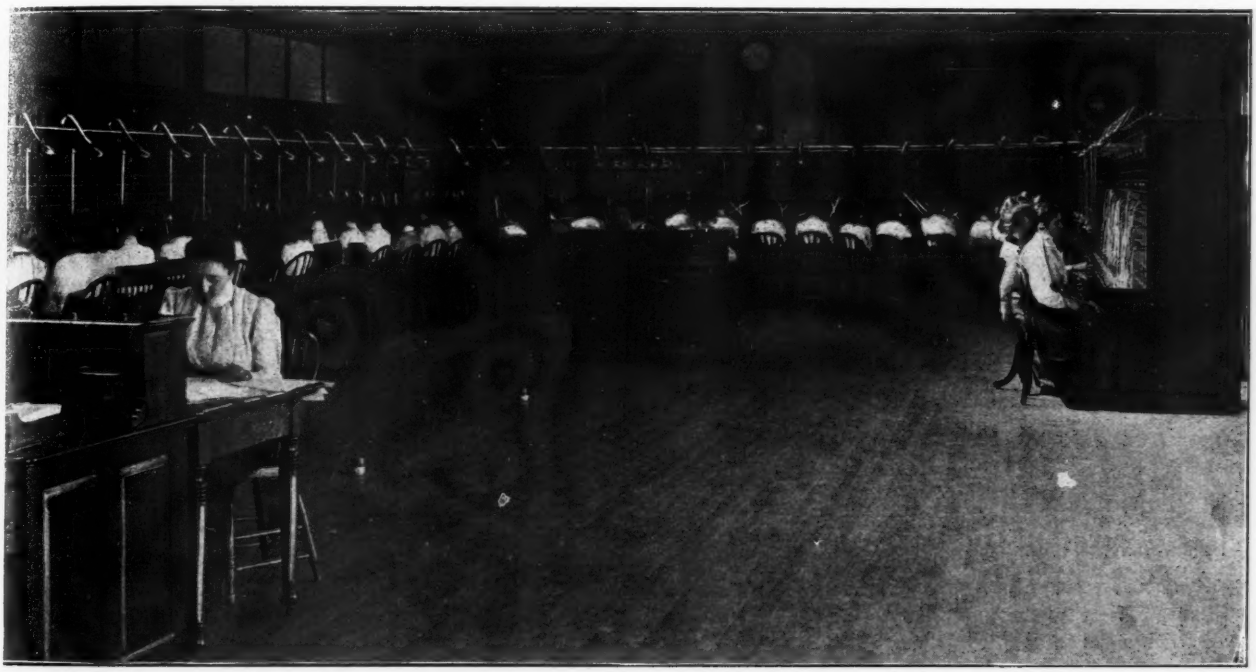
Telephone Connections between France and Italy.

A new telephone line connecting the French and Italian long-distance telephone networks was opened on January 1, when official greetings were exchanged between members of the French and Italian governments. So far the line does not extend into the southern parts of Italy, but only into the northern regions about Milan and Turin; connection with Rome has not yet been completed. The line crosses the Alps and its completion marks the first telephonic conversation between the two countries named.

Independent Telephone System of Philadelphia Successfully Inaugurated.

On the morning of January 1 the new exchange and headquarters of the Keystone Telephone Company at Second and Sansom streets, Philadelphia, was opened, and a party of invited guests had the privilege of using the wires of the new system for the first time. The occasion was marked by an informal reception and luncheon in the executive offices of the company.

The building in which the exchange is installed was formerly known as the Commercial Exchange, and is very well situated and constructed for the purpose of a telephone central office. The interior has been entirely rebuilt and is weatherproof throughout. The building is five floors in height, with a large light-well in the centre. The company is retaining for its own use the three upper floors, the fifth floor being given over entirely to the exchange room and retiring rooms for the operators. The system used is that of the Kellogg Switchboard and Supply Company, a full multiple switchboard for 7,200 subscribers having been provided and planned. So far the company has put down 1,050 miles of ducts in the central section of the city between the two rivers, and over 1,000 manholes have been built. For the present three exchanges will be operated, one of them being in West Philadelphia. The exchange is expected to be in full commercial operation in five or six weeks. At present it is lacking in some essentials of completion. The officers of the Keystone company are: President, R. H. Foerderer; secretary and treasurer, W. H. Clark; general manager, Charles E. Wilson; chief engineer, Louis Duncan, of New York.



CITIZENS' TELEPHONE COMPANY, SHOWING MAIN SWITCHBOARD.

The London Telephone Situation.

The agitation against the terms of the Post Office telephone service in London has been pushed on with much vigor both by the London County Council and the press. After a deal of public denunciation on the part of several members of the London County Council, this body organized a deputation to the Postmaster-General praying for a reduction from £17 to £12 per annum and asking that the £5 toll rate should be reduced to £3. Mr. J. W. Benn, the leader of the deputation, pointed out how unreasonable was the proposed subscription, and, as has so often been done before, emphasized the fact that in no other European country is the tariff higher than £10. But an agreement has recently been ratified between the company and the Post Office, and this, coupled with Lord Londonderry's reply to the above deputation, practically precludes any immediate possibility of modification. One point of view from which the Post Office authorities may possibly argue, and which I do not remember having seen mentioned before, is that they draw a royalty from the company. Thus, if by reason of government competition the company were compelled to reduce its tariff its resultant revenue would be correspondingly reduced, from which it follows that the government royalty would suffer, and for some years, at least, the magnitude of the Post Office telephonic business could not be expected to counterbalance this loss. That the company is quite satisfied with the present condition of things is evidenced by the following extract taken from one of its circulars inspired by the above agreement: "The real and underlying principle of the agreement seems to be that for the future there is to be mutual cooperation between the Post Office and the company in the development of the telephone system in London. . . . In other words, it will be 'competition' as regards quality of service, and 'cooperation' as regards working arrangements." Truly, the realization of the government telephone service is not value for the anticipation, but it is only another lesson to us all not to attach too much faith to the utterances of our political ministers. The promises made by Mr. Hanbury at the time of the telephone enquiry a few years ago have left a somewhat sore place.

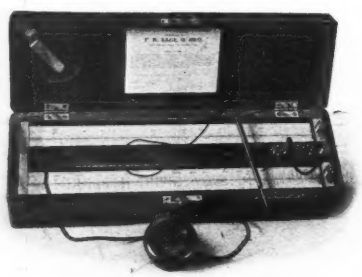
American Telephones in England.

The General Post Office has just ordered its entire equipment of telephones for London from the Western Electric Company's Chicago works. This is for the apparatus to be used in the new municipal installation.

An Improved Direct-Reading Ohmmeter.

The ohmmeter is a modified form of Wheatstone slide wire bridge self-contained with its battery and a telephone as an indicating instrument, and so arranged as to give immediate direct readings of the resistance of any object connected with its terminals. In its modified and improved form, lately brought out by Messrs. F. B. Sage & Brothers, New York, it is claimed that considerable advance has been made upon former types.

Two arms of the bridge are formed by the slide wire and the third and fourth by the known and unknown resistance, respectively. An unknown resistance being in circuit, a suitable known resistance is plugged in and a point is sought for on a wire with a stylus where no sound is heard in the telephone receiver. This point of silence is exceedingly sensitive, a deviation of one-hundredth of an inch from the exact point producing a distinct noise in the telephone receiver, which is in series with the indicating circuit.



DIRECT-READING OHMMETER.

The instrument receives its source of energy from a battery in the lower part of the box which is cut in circuit by a key in the telephone, and automatically disconnects itself on laying the receiver down, thus saving the battery.

There are four known resistances, any one of which can be connected in circuit by the manipulation of a single plug, thus producing four sets of scale readings along the slide wire, giving the instrument a range of from one one-thousandth of an ohm to 200,000 ohms. The plug contact is claimed to be of a much more substantial character than any plug contact on resistance measuring instruments. The plug is connected with a stout but very flexible cord and fits in an all-metal socket which is reamed to accurate taper fit for the plug, and therefore can never change due to warping of the rubber base on which it is mounted. Moreover, there is only one friction contact in series in the plug circuit instead of two, as is the case with the ordinary plug arrangement. The makers have found that this is a most marked improvement, and that where it was necessary before to use care to see that the plug was tight, the most careless fitting of the plug into its socket now gives results which are exceedingly satisfactory.

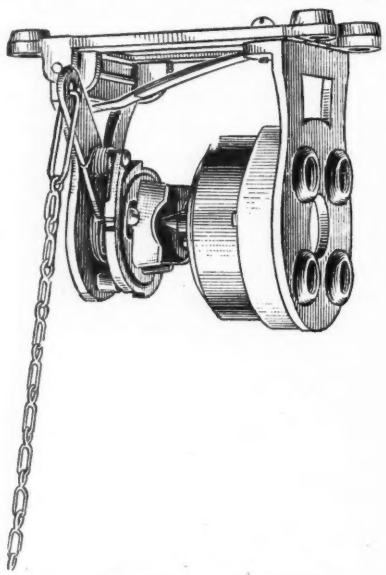


FIG. 1.—ROTARY CEILING SWITCH.

Moreover, there is only one plug contact in the entire bridge circuit which is a gain over ordinary arrangements for this work, for it is well known that a multiplicity of plug contacts produces proportionate errors.

The scale of the direct-reading ohmmeter is engine-divided. The telephone which was formerly placed in a separate compartment in the lower part of the box is now placed in a more convenient position under a clip in the upper part of the case and additional space is thereby secured for batteries which are contained in the lower part of the instrument.

The coils of the instrument, four in number, are wound with care and elaborately protected from corrosion or mechanical damage.

The great feature of the instrument is its exceeding rapidity in determining a resistance. The point of silence on the slide wire can be found in less than ten seconds by an inexperienced operator.

New York Electrical Society.

The twenty-fifth meeting of the society will be held at the College of the City of New York, corner Lexington avenue and Twenty-third street, on Wednesday, January 15, at 8 P. M. Dr. F. A. C. Perrine, president of the Stanley Electric Manufacturing Company, formerly professor of electrical engineering at Leland Stanford University, at Palo Alto, Cal., will deliver a lecture on "Water-Power Conditions and Power Transmissions on the Pacific Coast." The work being done in California includes the longest transmissions and highest voltages in the world, and in regard to these Dr. Perrine will lay before the members data and practical points of the most valuable character.

Rotary Ceiling Switch.

A new rotary ceiling switch, containing many unique and important improvements, has been recently placed on the market by Messrs. J. Jones & Sons, of 66 Cortlandt street, New York city. The switch is used in conjunction with the regular snap switch and has a rotary cam movement. It is simple in construction and can be easily detached by pressing a spring which releases the clutch holding the key of the switch. By this means it is made very convenient for wiring purposes, as all the parts are left open and exposed so that it can be rewired without removing it from the ceiling where it is placed. Fig. 1 illustrates the switch with the clutch in position and ready for operation. Fig. 2 illustrates the clutch thrown open and the switch ready for wiring.

Long Telephone Lines in Europe.

Consul-General Richard Guenther writes from Frankfort, Germany, that Paris is the centre of an international telephone wire net; its extreme ends are London, Hamburg, Berlin and (in connection with the French-Italian line about to be opened) Turin and Milan. The Paris-Berlin line is the longest, with about

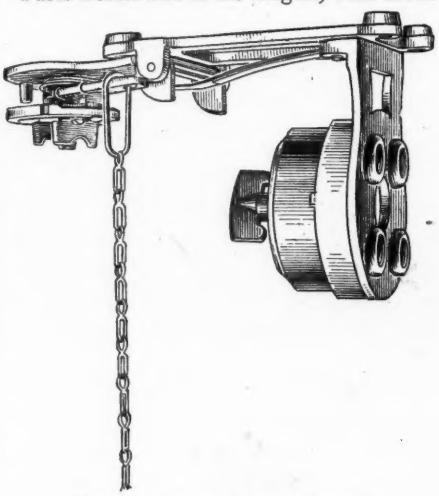
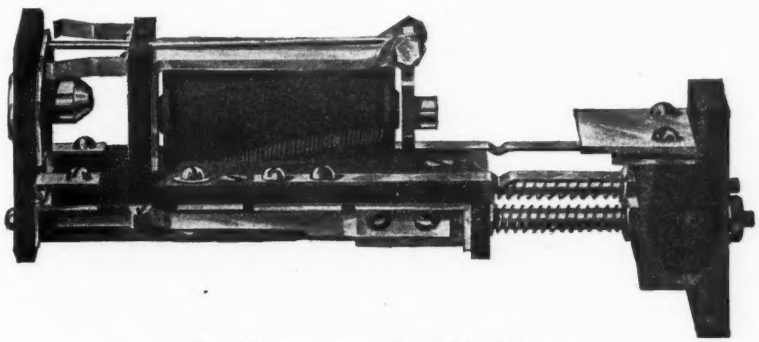


FIG. 2.—ROTARY CEILING SWITCH.

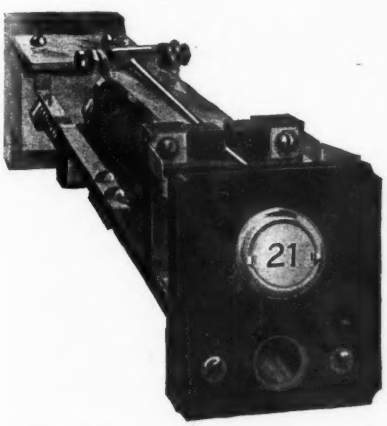
625 miles of wire. The Paris-Hamburg line is about the same. The distance from Paris to Turin, measured by an air line, is about 375 miles, but that between Paris and Milan about 470 miles. But all these lines are eclipsed in length by that between Paris and Cologne, not by the direct line, but by indirect connection, often rendered necessary by breaks in the other service. In such cases, a person in Paris desiring to speak to Cologne is connected *via* Berlin. This roundabout way increases the wire distance about 375 miles, making the total about 1,000 miles. The Cologne *Gazette* states that this does not impair the distinctness of the message, and no loss of time is noted in using this increased distance.

New Telephone Express Switchboard.

The Sumter Telephone Manufacturing Company, of Sumter, S. C., has recently introduced what it calls the "Bull's-Eye" express switchboard. The drop and jack is of the self-contained combined type, and one of its special and distinctive features is that the shutter falls inwardly, which is believed to be an advantage over all outwardly-falling shutters. It can not be thrown by accidental contact with the operator's hand, plug or cord while operating the board in answering calls and establishing connections. The clicker or shutter catch holding the shutter in its restored position is protected by the shutter falling inwardly, as it is concealed behind the shutter and drop front, eliminating the possibility of the shutter being thrown by any other than its normal means. The shutter is mechanically self-restored by the point of the plug immediately upon its entering the jack.



SIDE VIEW OF THE "BULL'S-EYE" DROP.

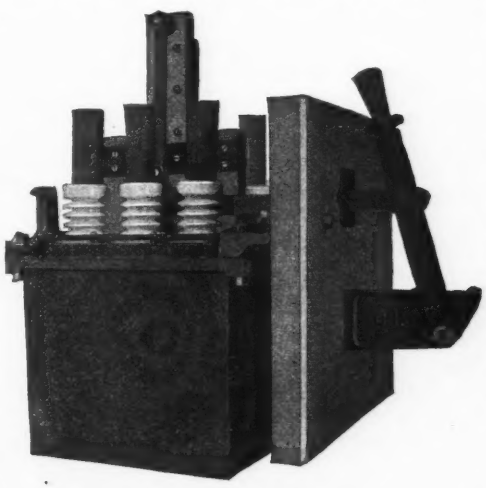


FRONT VIEW OF THE "BULL'S-EYE" DROP.

The drop may be easily and quickly withdrawn from the front of the switchboard cabinet. All of its parts are easily accessible and interchangeable. The drop coil is removable without having to unsolder any of its connections.

The drop is constructed so that it is susceptible of the most sensitive adjustment. Drop coils are cut out of the talking circuit as soon as the plug enters the jack.

The disappearance of the "bull's-eye" number signal, which is mounted on the shutter, may be easily detected from an oblique angle as well as position immediately in front of the drop section. The clearing-out or "ring-off" drops are of the tubular type, the armor being bored from solid Swedish rod. These drops are exceedingly sensitive, present a high impedance, and are bridged across the cord circuit. Each drop is provided with a reliable night-bell circuit, closed under a single contact spring actuated by the gravity of the shutter.



MANUALLY-OPERATED OIL SWITCH.

A Manually-Operated High-Tension Oil Switch.

The accompanying illustration shows a type of oil switch for handling high-tension currents, manufactured by the G. I. Company (General Incandescent Arc Light Company), and intended for use on circuits up to 6,600 volts pressure, with capacities up to several hundred amperes. The switch consists essentially of a cast-iron oil receptacle in which all of the live parts of the switch are submerged, the connecting cables running through porcelain insulators in the iron cover. The switch is operated by a simple mechanism controlled by the handle shown on the right, which is mounted on the front of the switchboard. All of the high-tension parts are behind the board and are completely cut off from any possibility of contact with operatives. The same switch is made in a variety of forms for different capacities and is also provided, when desired, with automatic overload release apparatus, making it virtually a circuit-breaker as well as a switch. The illustration shows a switch adapted to three-phase circuits, but the same variety of apparatus is made up also for quarter-phase work and for single-phase circuits. The great switches used on the heavy transmission lines of the Chicago Edison Company, which are described elsewhere in this issue, are also manufactured by the same makers.

New Types of Voltmeters.

A new line of voltmeters, containing the permanent magnet movements of the same kind as the regular line sold by the Whitney Electrical Instrument Company, but of a smaller size, has recently been placed on the market by Messrs. Machado & Roller, of 203 Broadway, New York city, the general selling agents for this company. The cases are of spun brass and are highly polished and lacquered and very attractive in appearance. The body of the case measures six inches in diameter and the flange at the base is seven and a half inches in diameter. These instruments are particularly designed for isolated plant work, where the combined qualities of accuracy and neatness are required. They are rapidly receiving much favor among those whose space is limited and who need small instruments of this sort.

A NEW TYPE OF VOLTMETER.

Chicago Electrical Notes.

(By Our Special Correspondent.)

A NUMBER of interviews with prominent business men, published in the new year editions of the daily press, predict a future of continued prosperity for the United States. Some doubt is expressed as to whether our present enormous export business will continue, but there is a general feeling that the interior trade will remain in the same healthy condition which it now enjoys and that markets will be found for all our manufactures. If these predictions hold good, the Central West will make even a more remarkable showing in the next census than it did in the last. This seems to be the prevailing opinion of manufacturers in the West, who claim that it is the logical field of greatest development, not alone on account of location, but because of its great natural advantages and supply of raw material. When the story of the next decade shall have been written, in nothing will the West stand more prominent than in its electrical development, and one factor which will play a part in this progressive movement to an unusual degree is the young man. This was forcibly brought to my attention, as especially applicable to the electrical industry, in a conversation with a prominent manufacturer some weeks ago. In going over the field it was surprising to see the large majority of prominent concerns which are in the hands of men who at their age twenty years ago would not, in the business world, have been considered much beyond the time of their apprenticeship, and they are throwing all of their energy and intelligence into the game. Of course there are a few pioneer firms located here and there, but the actual heads of these firms are young men so far as their years are concerned—they are simply old in experience. The vast majority of electrical enterprises which have been born in the last decade (and there are many of them) were promoted by young men and are managed by young men.

The great western universities are turning out, each year, young men with a practical education as well as a theoretical one. These are hopefully looking to the future, and are not afraid to spend two or three years in the shops to add to their practical knowledge of things. Working alongside these graduates are less fortunate but no less ambitious fellows, who, catching the inspiration, are determined to carry their side of the burden. Many of these are availing themselves of the advantages offered by correspondence and night schools and are pushing their fellow workers for first place. It is of this stuff, combined with some of the best products of the East, the South and the far West, that the men are being made who are to continue to develop the western country and make it the wonder not only of America, but of the world.

The annual police report of Chicago places the number of street car accidents for 1901 at 924 as against 861 for 1900. In these accidents 999 persons were injured in 1901 and 942 in 1900. The number of deaths resulting from these accidents was 77 in 1901 and 102 in 1900.

The apparent collapse of the Everett-Moore Syndicate came as a surprise to most of those who had watched the rise of this gigantic effort at trolley-line consolidation. There are some out here, however, who say they have been looking for such a fall for some months. Of course it is always easy to say one has foreseen an event after its happening. A prominent railway man in speaking of the rise and fall of this concern said the other day that there was nothing wrong with the scheme, the scheme was all right and feasible, but the trouble was in biting off more than one could chew.

The Crane Company, of Chicago, after figuring on the year's business, decided to show its appreciation of each one of the vast army of employés in its service by presenting new year's gifts which should represent a certain per cent of the company's earnings. The books showed that this present would amount to $125,000, and, on the last day of the year, each employé was handed his pro rata of this princely sum. Such liberality as this deserves to be especially mentioned.

The popular protest against the present street railway régime in Chicago may or may not lead to improvement. The politicians are interested and a legion of new ideas and schemes for bettering the service has swept down upon the city. Municipal ownerships of course is much talked of. Now and then above the smoke of this preliminary battle, a mirage of some big railway financier like Tom Johnson is seen, and some of those looking at it, say he is headed Chicagoward and is going to buy out the local railways—"lock, stock and barrel"—and reform them into an ideal system in which transfers to all parts of the city will be given, and the interior of a Chicago street car, with its two rows of tortured "strappers," shall cease to resemble the inside of a packing-house refrigerator, where hams and hogs are swung up to chill. The latest plan suggested to better conditions is to form a citizens' stock company, in which every Chicagoan who is so disposed may own a limited amount of stock, to be operated under franchises which shall guarantee the reforms now demanded. Meantime the present railway companies are doing business at the same stands and are no doubt managing to get three meals a day and the proper number of hours for sleep.

The X-ray is doing all sorts of stunts out here in the West, if current reports are to be believed. It is curing cancer, locating bullets, establishing the truth or falsity of doctors' diagnoses, etc., etc. Perhaps the most unique bit of work which is accredited to this electrical device is the discovery of a live snake in the stomach of a patient who for years has been suffering from an ailment which the doctors failed to diagnose.

The American Steel and Wire Company has adopted, and notices have been posted in all works of the company, making effective January 1, 1902, a pension department, which provides for the pensioning of old and faithful employés, in accordance with their terms of service. All employés of the American Steel and Wire Company, or its predecessors, will be eligible to participate in the benefits. The funds to provide pensions will be furnished by the company, the employés contributing nothing. From 25,000 to 30,000 men are employed by the company.

The Referendum League, of Chicago, is at work securing signatures to a petition for having placed upon the ballots in the coming elections the question of municipal ownership of the traction lines of the city. To do this the signatures of 104,000 voters are required. The league claims that 60,000 of these have already been secured.

Chicago, January 4, 1902.

Book Review.

"Electromagnets—Their Design and Construction." By A. N. Mansfield. 3½ by 6 inches. 155 pages. 36 illustrations. Boards. New York. D. Van Nostrand. Supplied by the ELECTRICAL REVIEW at 50 cents.

Mr. Mansfield has produced an excellent handbook of a practical character on the design and construction of electromagnets, giving working data that will be appreciated in the machine shop and factory.

CURRENT ELECTRICAL NEWS

COMMERCIAL NEWS

DOMESTIC AND EXPORT

A NEW CHILEAN CABLE—A commercial house has offered to lay a submarine cable from Puerto Montt to Sandy Point for $4,000,000.

JAPANESE ELECTRICAL ACTIVITY—A large surplus remains after the expenses of the Japanese Government have been looked after. It has been proposed to expend part of this surplus in the construction of railway and telegraph lines in Japan.

RAILWAY TO CHANGE POWER—The New York Central & Hudson River Railroad Company is said to be securing estimates of the cost for electrically equipping the Newton circuit of the Boston & Albany division. The company has considered the question carefully and now desires to secure estimates in order to make a final decision in the matter.

MR. YERKES'S LONDON PLANS—The chairman of the District Railway has announced that the electric power-house which is to be erected by the syndicate in which Mr. Charles T. Yerkes is interested would furnish power for the suburban services of a number of the lines, as well as to the underground railways. Arrangements with the trunk lines are now being made.

BRITISH TELEGRAPH NEWS—During the recent great storm the British telegraph service was rendered almost entirely useless by the havoc created by the storm. A widespread demand that the wires be placed underground has been created as a result. The wires between London and Birmingham have already been placed underground, and the system is being extended northward.

TELEPHONE ACTIVITY—It is announced that the owners of the Independent telephone lines in Wisconsin, Minnesota and northern Michigan will soon unite to form a long-distance toll-line service in the Northwest to compete with the Erie System. The Milwaukee Telephone and Telegraph Company, which is securing a franchise in Milwaukee, is said to be a part of the proposed new company.

LIGHTING IN FRANCE—The principal sources of light in France are electricity, gas, petroleum and candles. Of these candles are most common and are used exclusively throughout the country districts of Normandy by rich and poor alike. In some of the best hotels electric lights have been installed. In the business houses and in the streets gas is used principally at present, but electricity is slowly taking its place.

NEW INDIANA POWER COMPANY—The Tippecanoe Power Company has been organized recently with a capital of $1,000,000. Mr. J. J. Burkholder is among the principal stockholders. A dam is being built on the Wabash River near Delphi. It is planned to generate 5,000 horse-power for the purpose of furnishing electric lights for Delphi, Logansport, La Fayette and Monticello. It is expected that power will also be furnished for a new electric line to be built shortly between those cities.

NEW GEORGIA COMPANY—It is planned to form a company to be known as the Savannah Electric Company for the purpose of merging the property of the Savannah, Thunderbolt & Isle of Hope Railway and the Edison Electric Illuminating Company. This company is to issue $6,000,000 worth of securities. The American Loan and Trust Company, of Boston, will be the trustee for the new bonds.

THIRD-RAIL IMPROVEMENTS—The New York, New Haven & Hartford Railway Company is preparing to make improvements on its third-rail system between Hartford and Bristol, Ct. Machines of higher voltage are to be placed in the Berlin power-house and heavier cables are to be placed in position. Substations for transforming the current are to be erected at Hartford, New Britain and Bristol. It is planned to have uniform voltage for the entire service and to establish a more frequent express service between Hartford and Bristol.

PHILADELPHIA RAILWAY FRANCHISES—The Widener-Elkins Syndicate, which controls the Union Traction Company, and operates the street car lines in Philadelphia, is said to have secured the franchises and rights which were granted by the legislature and city councils to a group of men headed by Congressman Robert H. Foerderer, Jr. These franchises include surface, elevated and underground railways in Philadelphia. The securing of these franchises would give the company control of all the railways and franchises in Philadelphia. These are the franchises for which ex-Postmaster John Wanamaker offered to give the city $2,000,000, if they were turned over to him.

A VICTORY FOR THE WESTERN UNION TELEGRAPH COMPANY—Judge J. G. Slonecker, of Topeka, Kan., special referee, holds that the law reducing telegraph rates is unconstitutional, because it confiscates property. The law was passed by the Kansas Legislature of 1897. It cuts the tolls about forty per cent. Twenty-five-cent messages were reduced to fifteen cents. The company refused to comply with the law. A number of persons presented a lot of telegrams at the reduced rates, and when the company declined to send them they brought suit for damages. They wanted $100 damages for each message which the company refused to send. The case finally reached the District Court and Judge Hazen appointed Judge Slonecker as referee to hear the evidence and submit findings. Judge Hook, in the Federal Court, declared the law unconstitutional several months ago. Judge Slonecker recently took the depositions of the general officers of the Western Union Company at New York city.

IMPORTANT TO WEEKLY PUBLICATIONS—A few days ago an announcement was sent out from Chicago to publishers in general stating that the Post Office Department, at Washington, had ruled that a subscription to any publication entered as second-class matter must be discontinued when the time for which it was paid in advance had expired. The attention of the department was called to this and an official notice was sent to all postmasters by the Hon. Edwin C. Madden, Third Assistant Postmaster-General, requesting them to notify publishers that the statement as above given was untrue and misrepresented the attitude and purpose of the department. The report, it was stated, grew out of a ruling of an individual case of a New York publication which was carrying an enormous list of expired subscriptions which were largely first induced by premiums. Mr. Madden writes: "There has been no new ruling in this regard, and reasonable credit subscriptions to legitimate publications are unobjectionable under the law and regulations as heretofore."

THE EVERETT-MOORE EMBARRASSMENT—The Everett-Moore Syndicate, whose headquarters is in Cleveland, probably the most extensive owner of electric railways in the country, has come to grief. A committee of Cleveland bankers, representing the creditors, took charge of the financial affairs of the syndicate last week, and is now in control of all its properties. Nearly $100,000,000 is involved in the failure, which is generally supposed to have been caused primarily by ambitious attempts to do too much on its capital, when the tightness in the money market prevented the company from getting the funds necessary to complete the work begun. As far as can be ascertained the traction ventures of the syndicate are all right and in good shape. The members of the Everett-Moore Syndicate are H. A. Everett, E. W. Moore, D. Mahler, C. W. Wason and J. B. Hanna. Many of Cleveland's wealthy men are stockholders. Among the railroads which the syndicate controls are the Cleveland City Electric Railway Company; the Cleveland, Painesville & Eastern Railway and its branches; the Detroit United Railways, comprising all the street railways of Detroit; the Toledo Railways and Light Company, which controls all the street railways of Toledo and its suburbs; the Northern Ohio Traction Company, which controls the street railways of Akron and Canton, and a line from Cleveland to Akron and Canton to Massillon; the Lake Shore Electric Railway, a consolidation of lines from Cleveland to Detroit. All these companies are in as good financial shape as possible. The syndicate also owned the Federal Telephone Company, United States Telephone Company and the Cuyahoga Telephone Company, all independent lines, and had heavy holdings of many other kinds of investment. The stock of the various companies controlled by the syndicate amounts to over $50,000,000 and the bonds to about the same amount. It was the Federal Telephone indebtedness which precipitated the trouble, and the committee in charge of the syndicate's affairs will first attempt to raise funds to pay this off. This committee, which is now in charge, consists of H. R. Newcomb, Colonel Myron T. Herrick, Colonel J. J. Sullivan, Calvery Morris, E. G. Tillotson and Kaufman Hays, all of Cleveland.

ELECTRIC LIGHTING

NEWPORT, KY.—It is announced that plans for a power plant have been completed which will furnish power to manufacturing concerns and business houses here. It is to cost $50,000.

LIBERTY, N. Y.—The Liberty Light and Power Company has made reductions ranging from ten per cent on $5 to thirty-five per cent on $40 on all accounts paid on the fifteenth of the month following.

NEW ORLEANS, LA.—The controller is advertising for proposals for a lighting plant to be owned by the city after ten years' operation by the builders. The city electrician and others are at work upon the specifications.

CORSICANA, TEX.—At a special meeting of the city council yesterday afternoon a franchise was granted to the Corsicana Gas and Electric Company for twenty-five years, the city reserving the right to fix the rates at periods of ten years.

CHARLOTTE, MICH.—The council has voted to discontinue the street lighting contract with the Charlotte Electric Company. Unsatisfactory service is given as the reason, although it is supposed that the probability of a municipal plant is the real cause.

DULUTH, MINN.—The Commercial Light and Power Company will shortly add 1,000 horse-power to its plant of engines. The company has spent a large amount in improvements to its station in the past few months and proposes to spend more during the coming year.

BERKELEY, CAL.—President John A. Britton, of the Berkeley Electric Light and Gas Company, states that the rate for incandescent lights to the municipality will be reduced on February 1 by one-third. A new contract with the city is to be drawn up which will be more to the city's advantage.

WILMINGTON, DEL.—The city has awarded to the Wilmington City Electric Company the lighting contract for ten years, beginning December 31. Mr. John A. Rigg, president of the company, was present at the meeting of the council and stated that it was proposed to spend about $200,000 in improving the plant.

ENGLESIDE, PA.—Work on the new powerhouse of the Lancaster County Railway and Light Company is being pushed ahead as long as the weather will permit. Over 100 men are engaged at present in the building operations. It will be many months, however, under the most favorable conditions before the plant is finished.

SANTA ROSA, CAL.—A plan is under way to harness the waters of Sulphur Creek north of Cloverdale for the purpose of generating power to furnish electricity for the lighting of the city of Cloverdale and the big wineries and buildings of the Italian-Swiss colony in the town of Geyserville. The leading spirit in this progressive step is Andrea Sbarboro, capitalist and banker, of San Francisco, who is also secretary of the Italian-Swiss colony.

TELEPHONE AND TELEGRAPH

BEAVER, UTAH—The work of constructing the telephone line from Beaver to Milford is being pushed along rapidly. The line has been completed as far as Adamsville.

ANSONIA, CT.—The telephone exchanges of the Southern New England Telephone Company, which are situated in Ansonia and Derby, are to be united in a union station located in Derby. For this purpose a new exchange building is being erected.

LA CROSSE, WIS.—The branch of the La Crosse & Southeastern Telephone Company, which runs from Hillsboro to Viroqua, has been leased to the Hillsboro & Wonewoc Telephone Company. This company is now making extensive improvements upon the lines.

SPRINGFIELD, OHIO—The Springfield Home Telephone Company and the Xenia Citizens' Telephone Company have filed articles of consolidation. The capital stock of the new combined companies will be $500,000. Mr. U. S. Dryfoos, of Cleveland, will be the president.

FRANKLIN, MICH.—The Michigan Telephone Company has begun the work of building a line from Houghton to Franklin. The poles for this line have already been set and the work of stringing the wires will soon be started. The same company is building a line from Houghton to Red Ridge.

PORTLAND, ME.—A considerable activity in the Independent telephone service from Portland through the villages and rural communities of southwestern, central and northwestern Maine, is reported. The Dirigo Telephone Company, at present, has about 250 miles of line which is practically completed. This company is also preparing to make large additions to its present facilities and to install the most modern equipment throughout its system. The company has been granted permission to enter Augusta by the municipal authorities.

AUTOMOBILE NOTES

AN IMPORTANT TEST—A carriage has been started from the Toledo factory of the American Bicycle Company en route to Hot Springs, Ark., for the purpose of testing it. The route followed will be from Toledo to Cincinnati, Cincinnati to Louisville, Louisville to Memphis, Memphis to Little Rock, and Little Rock to Hot Springs. The roads in that part of the country are said to be in bad condition at present and the trip should furnish a most useful test of the carriage.

COPENHAGEN AUTOMOBILE EXHIBITION—An exhibition of automobiles will be held in Copenhagen, Denmark, from April 11 to April 27, 1902. This exhibition is to be under the auspices of the Danish Automobile Club and the Society for the Promotion of Industrial Arts. It is designed principally for automobiles, but some space will be devoted to motor cycles and articles which relate to the driving of automobiles. All those who desire to participate in the exhibition should send as complete information as possible, together with illustrations of their machines if convenient, to Industriforeningen, Copenhagen, as soon as possible.

ELECTRIC RAILWAYS

RAWLINS, WYO.—The aerial tramway from the Ferris-Haggarty copper mine, at Battle Lake, to the Boston-Wyoming smelter encampment has been agreed upon. Mr. Charles E. Knapp is president of the company.

DAVENPORT, IOWA—A new electric road to run from Davenport to Cedar Rapids by the way of Tipton and Mt. Vernon is proposed. A partial survey has already been made and the construction of the line promptly seems assured.

PORT JERVIS, N. Y.—The Port Jervis Street Railway has been purchased by Mr. Charles R. Horn and Mr. Ralph H. Beach at a receiver's sale. The price paid is said to have been $500 above the encumbrances prior to the appointment of a receiver.

PORTSMOUTH, VA.—Plans are under way for connecting the city of Portsmouth with the towns of Churchland, Suffolk, Newport News and other near-by points. This will probably be done by making extensions which the Norfolk, Portsmouth & Newport News Railway Company has planned.

TIFFIN, OHIO—The contract for the construction of the Tiffin & Southern Electric Railway has been let to Williams & Son, of Lynchburg, Va., who will construct and equip the road, work beginning at once. The line will start at Tiffin and end at Kenton, a distance of about fifty miles. It is proposed to have the line in operation within a year.

SPRINGFIELD, OHIO—Mr. Frederick J. Green, who is the manager of the Dayton, Springfield & Urbana Electric Railway Company, states that those who were interested in the construction of a line from Lebanon Junction to Dayton for the purpose of connecting the Dayton, Lebanon & Cincinnati Railway Company's line with Dayton, are to begin the construction shortly.

CLEVELAND, OHIO—The Lake Shore Electric Line announces that it will run through electric cars from Toledo to Cleveland in four hours. The Lake Shore & Michigan Southern Railroad makes this run by fastest trains in two hours and thirty-five minutes, the average train requiring three hours. The fare on the electric line is $1.75 as compared with $3.25 on the steam line. President Maher, of the trolley road, expects to get a large share of the through passenger business besides doing considerable freight and express traffic.

CLEVELAND, OHIO—The complications arising from the trouble of the Everett-Moore Syndicate will affect a number of electric railway schemes in various parts of the country. At Springfield, Ill., four lines had been projected by this concern to run from Springfield, as a central point, to the cities of Bloomington, St. Louis, Decatur and Jacksonville. A survey of the Decatur line has been completed. It is believed, however, that any embarrassment of these schemes will be only temporary, and the roads will no doubt be built as the territory is considered very valuable.

ELECTRICAL SECURITIES

The opening of the new year in financial circles is encouraging for better prices for stocks. The closing prices on Saturday, January 4, averaged 2 or 3 points in advance over those of the previous week. A hopeful spirit seems to pervade all the financial centres of this country, and reports from abroad indicate that business is brisk on the stock exchanges of London and Paris and a fairly general rise in the price of securities has occurred.

Respecting the New York market, stock operations increased nearly one-third in volume over the preceding week, and bond dealing reflected a material improvement both as to the volume of transactions and the character of the buying. The professional element looks for a continuation of the upward movement, and barring some unforeseen event this is pretty safe to count upon. All the machinery of Wall street seems to be backed by the great prosperity of the country, and the approaching period of monetary relaxation, due to the letting loose of millions in dividends on this market, will no doubt preserve the present higher level of prices.

Altogether the new year opens auspiciously and notwithstanding the embarrassment of the National Asphalt Company, the Everett-Moore Syndicate and the Crude Rubber Company, the market shows a steady upward trend.

The great banks of New York begin the new year with showings of a prosperous year just ended, and are evidently in excellent condition.

ELECTRICAL SECURITIES FOR WEEK ENDING JANUARY 4.

New York:	Closing.
Brooklyn R. T.	66⅞
Con. Gas.	219¼
Gen. Elec.	280
Man. El.	137
Met. St. Ry.	163
Kings Co. Elec.	180
N. Y. & N. J. Tel. Co.	169
Telep., Tel. & Cbl. Co.	6½

A deed of trust, pledging all real estate, stocks, patents, etc., of the Electric Vehicle Company to the Morton Trust Company, in consideration of $2,250,000, has been filed at Hartford, Ct.

There is said to be a bullish pool operating in Westinghouse Electric. It is said to be composed largely of Pittsburgh gentlemen who are familiar with the affairs of the company and its prospects for business.

The *Wall Street Journal* of Monday, January 6, says: "The advance in Brooklyn Rapid Transit on Friday was regarded as a move against the short interest, which had become rather large. The stock has been something of a favorite short sale since the policy of the company in putting earnings into the property has made it pretty clear that the question of dividends is not likely to come up for a considerable time. Insiders have little to say further than that the company has a very valuable franchise, which, in itself alone, is, in their opinion, worth about all the stock is selling for, and that, with its control of the surface and elevated railroad traffic of Brooklyn, the property has a great future."

It is announced from Cleveland that the Everett-Moore Syndicate is practically solvent. Mr. R. Newcombe, chairman of the bankers' committee, declared that when the affairs of the syndicate have been adjusted and all the claims settled there would be a surplus of about $3,000,000. He further states that all the properties, with the exception of the Federal Telephone Company, are in excellent condition, but that that company is financially embarrassed. It is estimated that the liabilities of the syndicate, aside from the stock and bonds, is about $3,000,000, and of this over one-half is charged to the Federal Telephone Company and the remainder to the traction enterprises. Most of the claims are for labor and material. A divorce between the traction companies and the telephone companies is proposed and a possible sacrifice sale to the highest bidder, probably the Central Union Telephone Company, is talked of.

The earnings of the U. S. Steel Company for the three months ending January 1, it is unofficially reported, will show an aggregate of about $36,000,000, as compared with about $54,000,000 for the previous six months. Dividend action upon the stocks will probably be taken at the directors' meeting this week.

The installation of electricity on New York transportation lines is said to have increased earnings and the value of franchises immensely. The tax collector is said to be investigating.

Boston:	Closing.
Am. Telep. & Tel.	162
Erie Tel.	16
New Eng. Tel.	137
Mass. Elec. pf.	92¾
Westing. Mfg. pf.	86
Edison Elec.	245

At a meeting of the stockholders of the Erie Telegraph and Telephone Company, in Lowell, last week, it was voted to endorse the Kidder, Peabody & Company reorganization plan, described in the ELECTRICAL REVIEW last week.

Philadelphia:	Closing.
Elec. Co. of America	6⅛
Philadelphia Elec.	4⅝
Union Traction	32⅜
United G. I. Co.	115
Elec. Stor. Bat. c.	60
Elec. Stor. Bat. pf.	60

A director of the Union Traction Company says that this company is not likely to interest itself in the new "Ripper" franchises of that city nor in the Keystone Telephone Company.

Chicago:	Closing.
Central Union Tel.	40
Chicago Edison Light.	160
Chicago Telep.	225
Metropolitan El.	91½
National Carbon.	19
National Carbon pf.	82
Union Traction.	11¼
Union Traction pf.	47½

PERSONAL MENTION

MR. EDWARD S. BEACH AND MR. JAMES HAMILTON, retired, U. S. A., have associated themselves in all branches of law business, including patent and copyright cases as a specialty. The offices of the firm are at 53 State street, Boston, Mass.

MR. JOHN THAYER, prominent in railroad express service, has entered the firm of Faris & Thayer, well-known bankers and brokers, of 52 Broadway, New York. Mr. N. Townsend Thayer, of this firm, is a member of the New York Stock Exchange, and the house has a number of customers among the electrical fraternity.

COLONEL ROBERT C. CLOWRY, vice-president and general superintendent of the Western Union Telegraph Company, with headquarters in Chicago, was in a train wreck near Dallas, Ore., on December 6. His private car was attached to the train, but did not leave the track, and fortunately none of the passengers was injured.

MR. BENJAMIN K. HOWARD, lately connected with M. B. Austin & Company, of Chicago, has organized the Howard Electric Company, of Des Moines, Iowa. The company will do a general electrical supply and construction business. Mr. Howard had years of experience in Chicago in connection with leading electrical establishments of that city, and is well equipped to make a success in his new field.

MR. W. J. JOHNSTON, the well-known publisher, who was formerly identified with the field of electrical publication, has acquired large holdings of the company publishing the *Engineering and Mining Journal*, and has merged with it his semi-monthly publication *Mining and Metallurgy*. Mr. James H. McGraw, the former president of the *Engineering and Mining Journal*, has retired from that position, remaining a member of the board of directors, while Mr. Johnston becomes the president of the new consolidated company.

LEGAL NOTES

RAILWAY DAMAGES—Contributory negligence, however slight, of a person injured by being struck by a street car, is held, in Tesch *vs.* Milwaukee Electric R. & L. Company (Wis.) 53 L. R. A. 618, to preclude his recovering from the street railway company on the ground of negligence.

INSULATOR PATENTS SUSTAINED—A suit brought by the R. Thomas & Sons Company for the Boch patent covering the invention of the glaze-filled porcelain insulator and process of making it has been decided in favor of the plaintiff, a supplementary reaffirming opinion having been handed down by the Court of Appeals of the District of Columbia on December 26. The opinion states: "Boch has conceived and perfected that which others have striven for in vain. Characterized in a phrase, his invention may be spoken of as a glaze-filled multi-part porcelain insulator. Its particular features have already been averted to. The process he employs and has patented seems peculiarly fitted to accomplish the end desired, but the fact that there may be others does not debar him from laying claim to the result attained, of which he seems to be the discoverer."

INDUSTRIAL ITEMS

THE AMERICAN HARD FIBRE COMPANY, Newark, Del., manufacturer of the insulating material known as "Insulite," will remove its factories from Newark, Del., to Wilmington, Del.

THE ELECTRIC APPLIANCE COMPANY, Chicago, believes that there is at least one place in every town where there is so much noise that they can not hear the telephone bell. The company is out with a cure for this trouble—a special, loud-ringing extension bell.

THE CLIFTON MANUFACTURING COMPANY, Boston, Mass., makes a rubber "double-coated" conduit which is announced to be proof against electrolysis or rust in work underground or under water. The conduit may be bent to any angle without cracking or injury.

THE AUTOMATIC SWITCH COMPANY has removed from Baltimore its manufacturing plant and main office to 131 Liberty street, New York. The company announces that it will be conducted on broader lines and will manufacture a larger and more varied assortment of automatic controlling devices.

THE AMERICAN BATTERY COMPANY, Chicago, Ill., states that the year just closed has been the most satisfactory in the matter of volume of sales of any year since it was established in 1889. The company manufactures the American types of storage cells, which are claimed to be non-infringing and protected by patents.

THE D. M. STEWARD MANUFACTURING COMPANY, Hancock, Tenn., and 107 Chambers street, New York, is a manufacturer of the material for electrical insulation known as "Lava," which it believes to be much better than rubber or fibre for electrical work, because of its being one of the most refractory of substances.

THE CENTRAL ELECTRIC COMPANY, of Chicago, is distributing a new bulletin on D. & W. telephone protectors. This protector combines a high-tension fuse, a zinc coil, and a lightning arrester all arranged on one block, making an instrument of neat and compact design. A descriptive bulletin of this material will be sent free.

MESSRS. JAMES S. BARRON & COMPANY, telephone manufacturers, New York, are offering a prize to the engineer of a telephone company sending in, before June 1, 1902, the best short article setting forth the merits of the H-P glass insulated bridle ring and the uses to which these rings are best adapted. Full information can be had by direct application to the company.

THE UNITED TELPHERAGE COMPANY, 20 Broad street, New York, is meeting with success in the introduction of its electric system for elevating and conveying. This system, which was fully described in this journal, operates on solid steel overhead rails on an entirely automatic principle. It offers to send its most recent catalogue descriptive of the system to enquirers.

THE AMERICAN ELECTRICAL HEATER COMPANY, of Detroit, Mich., is sending out a neat souvenir of the season in the form of a check on the "National Bank of Prosperity" for "365 prosperous days." This check, which is dated January 1, 1902, and numbered, is countersigned by the president of the company, Mr. B. H. Scranton, and countersigned by the secretary and treasurer, Mr. John Scudder.

THE HUNTER FAN AND MOTOR COMPANY, Fulton, N. Y., is announcing its early readiness to receive orders for the Tuerk alternating ceiling fans for the season of 1902. This company is one of the pioneer companies in the manufacture of alternating fan motor apparatus, and its fans are in operation in all parts of the world. The company is represented in the East by E. B. Latham & Company, 136 Liberty street, New York, and for export sales, and in the West by the Western Electric Company.

THE BULLOCK ELECTRIC MANUFACTURING COMPANY, of Cincinnati, Ohio, and the Wagner Electric Manufacturing Company, of St. Louis, Mo., have established a foreign sales department with headquarters at Cincinnati. All foreign business, except that for Mexico and Canada, by the two companies will be handled by this new department, which is to be under the management of Mr. Frank G. Bolles. Mr. Bolles will also have charge of the work of the advance department, which has been under his charge for the past three years.

THE KELLOGG SWITCHBOARD AND SUPPLY COMPANY has sent out from Chicago, with its compliments, a beautifully printed catalogue, entitled "Terse Telephone Talk." The fine exhibit of this company at the Pan-American Exposition is illustrated in colors, and in addition its apparatus is described and many attractive illustrations presented. The catalogue is an excellent example of the printer's art, and can not fail to prove of interest to every telephone man in the country. The catalogue is sent out complimentary. It is from the press of Hugo Wittman, Buffalo, N. Y.

L. B. ALLEN COMPANY, INCORPORATED, Chicago, the original patentee and sole manufacturer of Allen soldering stick, paste, salts and commutator lubricant, has just completed and equipped with original labor-saving devices throughout a three-story annex to its former establishment. Its business has grown rapidly, and many new features were required to care for and facilitate this growth. These have been added, and the output so materially increased thereby that prompt deliveries of the largest orders can be made—a fact the market will appreciate. Its motto, "*prae ad supremum*" (forward toward the highest), is the keystone to its arch of success.

THE BISHOP GUTTA-PERCHA COMPANY, New York city, announces that it has had one of the most successful years of its existence. This company has been manufacturing high-grade rubber-insulated wires ever since 1847, and it makes the claim that all its wires are of the best grade and quality possible in the manufacture of such apparatus. Mr. Henry A. Reed, who has for many years been prominent in the telegraph field, has been with this company for twenty years as manager, and has spared no expense or effort to make the Bishop wires and cables of the highest grade manufactured throughout the field. The company is also making a specialty of elevated cables, traveling and standing cables for electric lights in elevators as well as annunciators. By a new process it fireproofs all its flexible cables without injuring the durability or quality of the cable.

THE FRINK REFLECTORS, which have received awards in every exposition in which they have been entered, more recently receiving the highest award at the Pan-American Exposition, Buffalo, where thirty-two reflectors were used in lighting the railway station and Transportation Building, have been adopted for use in lighting the art galleries of the Charleston Exposition, a species of lighting to which they are specially applicable, and in which they reach the highest results. This is an adaptation of the famous show-window reflector, which hardly needs any introduction to our readers, as it is in use in so many of the representative stores of the country. Mr. Frink, pioneer of the reflector trade, being the original patentee, has been in business nearly half a century. "Excelsior" seems to be the motto of this progressive house. The name "Frink" has always stood for all that is highest and best in the reflector line, the products reflecting not only credit on the maker, but on the contractor who installs them, and the consumers who use them. In addition to show-case and window lighting, store interiors, etc., this company makes a specialty of church and building lighting, art galleries, etc., no problem in lighting being too difficult for them to undertake to solve successfully.

THE HARRISBURG FOUNDRY AND MACHINE WORKS, of Harrisburg, Pa., has closed a highly successful year's business, it being about thirty per cent more in volume than in 1900. Prospects for the new year are very bright, contracts having been closed recently for engines aggregating over 5,000 horse-power. Some of the important orders are the following: One 600-horse-power engine, for the Dunbar (Pa.) Electric Company; one 550-horse-power D. C. engine, for the H. J. Heinz Company, Pittsburgh, Pa.; two 200-horse-power D. C. engines, for the Pennsylvania Steel Company; one 150-horse-power and two 100-horse-power for the United States Steel Corporation; two 500-horse-power engines, for the Wilmington (Del.) City Electric Company; one 500-horse-power engine, for the Metropolitan Electric Company, Reading, Pa.; two 450-horse-power engines, for the Lackawanna Iron and Steel Company; two 25-horse-power engines, for the American Stoker Company. The company has received in addition to the above, many other smaller orders as well as contracts for three complete steam plants, and there is every reason to believe prospects are good for about one-third more business over 1901 for the coming year. Tne prospects therefore for 1902 are very bright and ground has been broken for a new pattern shop building 170 feet long by 50 feet wide; the space now occupied by the pattern shop will be used as an erecting department. The engines above mentioned are the medium-speed, four-valve type, so well and favorably known to the trade desiring economical, close regulating engines. Complete specifications will be furnished promptly to prospective purchasers.